SUMMARY OF FOLIAR ASSESSMENT SURVEYS FOR OXIDANT INJURY TO FIELD CROPS IN SOUTHERN ONTARIO:

1971 - 1982

Ministry of the Environment
Ontario

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Summary of Foliar Assessment Surveys for Oxidant Injury to Field Crops in Southern Ontario: 1971-1982

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SUMMARY OF FOLIAR ASSESSMENT SURVEYS FOR OXIDANT INJURY TO FIELD CROPS THROUGHOUT SOUTHERN ONTARIO: 1971-1982

Ozone has long been recognized as the major component of the photochemical oxidant complex and as one of the most damaging of all air pollutants affecting vegetation. Although it has been associated with urban atmospheres due to the input of precursor pollutants in these areas its presence is now known to extend into rural, uninhabited areas a result of long range transport by regional air mass movements. In southern Ontario high ozone levels generally are associated with regional southerly air flows which have passed over numerous urban and industrialized areas of the United States and which are carried across the lower Great Lakes where they undergo rapid dispersion as they encounter unstable conditions near the northern shores of Lake Erie. Contributing to this influx pattern are the more localized downwind urban effects which can add to the already high background levels.

In an effort to assess and compare the annual severity of foliar ozone injury on sensitive Ontario crops, Phytotoxicology personnel have conducted visual assessment surveys throughout the major production areas in southern and southwestern Ontario since 1971. This report presents and summarizes these survey findings, and where possible, provides additional information on the nature of the problem and its possible impact on crop production practices.

The extent of the assessment coverage and the crops and number of varieties examined each year are shown in the following table.

Crop Examined	Year	No. Visual Examinations	No. Different Crop Varieties Examined
White bean	1971	21	3
	1972	43	3
	1973	50	3
	1974	33	3
	1975	39	3
	1976	54	3
	1977	28	3
	1978	11	3
	1979	13	5
	1980	21	5
	1981	17	4
	1982	48	4
Tomato	1974	115	28
	1975	71	18
	1976	70	20
	1977	83	23
	1978	35	14
	1979	51	32
	1980	33	15
	1981	46	19
	1982	48	20

Crop Examined	Year	No. Visual Examinations	No. Different Crop Varieties Examined
Potato	1977	37	11
	1978	35	9
	1979	28	11
	1980	37	9
	1981	93	18
	1982	61	18
Tobacco	1977	33	6
Muck Crops (5)	1977	14	8

It is apparent from this table that in the 12 year period from 1971-1982, a total of 29 foliar injury assessment surveys of 9 sensitive crops were conducted either annually or intermittently comprising a total of 1268 visual foliar injury ratings on a total of 321 annually different crop varieties.

Complete details on the results of the individual surveys can be found in the following attached reports (Appendix).

Report Name	*Author*	*Appendix No.*
Assessment of Ozone Injury to White Beans in Southern Ontario: 1971-1982	*R.G. Pearson*	*1*
Assessment of PAN-type Injury to Tomato Crops in Southern Ontario: 1974	*D.B. Drummond*	*2*
Assessment of PAN-type Injury to Tomato in Southern Ontario: 1975	*D.B. Drummond*	*3*
Assessment of Ozone/PAN-type Injury to Tomato, Potato, Tobacco and Muck Crops in Southern Ontario: 1976-1978	*R.N. Emerson*	*4*
Assessment of Ozone and PAN-type Injury to Tomato and Potato Plantings in Southern Ontario: 1979	*R.N. Emerson*	*5*
Assessment of Ozone Injury on Potato and Tomato Plantings Across Southern Ontario: 1980 and 1981	*R.N. Emerson*	*6*
Assessment of Ozone Injury on Potato and Tomato Plantings Across Southern Ontario: 1982	*R.N. Emerson*	*7*

The following is a brief summary of the nature of the injury and the survey findings for each crop.

White beans

The bronzing or rusting of the foliage of white beans has been observed since as early as 1918 and was originally classed as a non-parasitic disease and referred to as sunscald. In 1961 the disorder was reported throughout southwestern Ontario and was associated with extensive yield losses. In 1968, the symptoms which first appear sometime between flowering and normal senescence and result in older leaves becoming senescent and abscising prematurely and younger, fully expanded leaves developing an upper surface bronze-coloured necrotic stipple were thoroughly documented and the disorder was found to be associated with the occurrence of elevated levels of atmospheric ozone pollution.

The annual Phytotoxicology visual assessment surveys which have been conducted throughout the major white bean production areas in southern and southwestern Ontario since 1971 have been conducted primarily to permit the comparison of the general severity of ozone injury each year and to relate the degree of foliar injury to ozone episodes and other conditions known to govern the response of the crop to ozone exposure.

The bronzing disorder was most severe in 1976 and least severe in 1972 and 1971. Injury in 1982 and 1981 was found to be light in severity. In most years injury severity was attributed to ozone episodes during the first 3 weeks of August, the time of maximum foliar sensitivity. However, it also was apparent that the reaction of the crop to potentially injurious ozone episodes is affected by other factors with drought stress having a significant protective effect. More detailed investigations in 1976 and 1977

revealed several other aspects of the bronzing syndrome on the white bean crop which have been summarized below:

1. *the severity of bronzing was directly related to the chronological age and physiological development of the plants and coincided with the period of maximum foliar sensitivity during the first 3 weeks of August.*

2. *no one production area was more severely affected than any other during the survey years even when adjustments were made for differences in plant age and maturity.*

3. *some slight differences in varietal sensitivity were detected but were found to be due to differences in plant age and thus did not represent a true genetic response.*

4. *the degree of root rot was found to fluctuate from one year to another and in the more severe case (1976) was associated with more severe foliar bronzing.*

In spite of the absence of any quantitative information on the effect of ozone bronzing on crop yield there has been evidence of major shifts in production areas with the major trend being towards a decrease in Kent County and a shift to the northern counties of Huron and Perth.

There has been general consensus that the acreage shift was due primarily to the severity of bronzing in the southern counties and the potential for greater yields in the less severely affected northern locations. However, a review of some of the agricultural statistics reveals that bronzing may not have been the sole reason for this shift, as:

1. *Approximately one half of the total reduction in white bean acreage in Kent County occurred from 1959-1970 and*

corresponded with yields which were, for the most part, above the provincial average.

2. *In spite of the fact that yields in Elgin County have generally been below the provincial average there has not been any decrease in acreage grown.*

and 3. *Although bean yields in Huron County were consistently below the provincial average up until 1968, significant acreage increases were experienced during that period.*

On the basis of this information it would appear that the yield of the crop has not totally influenced the growers' decision to increase or decrease their production acreage. These figures complicate the assessment of the effect of bronzing on the shift in bean production as it cannot be simplistically stated that the annual occurrence of the bronzing disorder in Kent and Elgin counties has reduced bean yields resulting in a decrease in crop acreage. Nor is it true that bean production in the more northern counties increased because farmers were able to produce higher yields under bronze-free conditions. There is no doubt that the bronzing syndrome has, in many years, significantly reduced bean yields and that bronzing has at times been more severe in the southern counties of Kent and Elgin. However, the acreage decrease in Kent County and the corresponding increase in Perth and Huron counties probably was influenced by several other factors which are discussed in the appended report.

Tomatoes

The Phytotoxicology investigation of peroxyocelyl nitrate (PAN)-type injury to vegetation began in Ontario following the report of unusual symptoms to commercial tomato crops in SW Ontario in 1972. The injury

was noticed by field representatives from the research division of a major canning company and samples were submitted to the Department of Plant Pathology, University of Guelph. After ruling out any disease problems the Phytotoxicology Section was notified and an investigation was initiated in 1972 and 1973.

The symptoms appeared on the lower leaf surfaces of middle-aged, rapidly growing compound leaves. The leaves toward the top of the plant usually displayed injury only to the most mature terminal leaflet, while leaves closer to the bottom (older) displayed more injury on less mature basal leaflets than on terminal leaflets. A thorough examination of the affected tissues in the histological laboratory confirmed that the injury resembled PAN symptoms. This information, together with the symptomology, the pattern of injury progression, the occurrence of high photochemical oxidant levels prior to injury development and the documented sensitivity of tomatoes to PAN were used as the basis for referring to the injury as PAN-type. However, as PAN had not been monitored in Ontario it was not possible to conclude that it was the causal agent.

In an attempt to further explore the cause of the injury complex a number of field and laboratory experiments were conducted during the period from 1978 through 1981.

Although the findings have not yet been published, the following conclusions have been drawn from the project:

1. *the symptoms which appeared under field conditions were related to days of elevated ozone and plants could be protected against symptom development through the frequent use of an anti-ozonant protective chemical spray.*

2. *there was no apparent relationship between the development of the symptoms under field conditions and the presence of SO_2 and O_3 as suggested in several research reports dealing with synergism between these pollutants.*

3. *the symptoms which were atypical of those caused by ozone were reproduced under controlled environment conditions by a very narrow dose range involving ozone exposure.*

and 4. *atmospheric PAN monitoring in 1980 and 1981 at Simcoe failed to confirm the presence of PAN in any significant quantities during periods when the PAN-type symptoms developed.*

On the basis of these experimental and atmospheric monitoring results the injury has been characterized as due to ozone exposure.

In summary, the annual survey findings which have been appended reveal that since 1974 injury severity has varied considerably in intensity with differences also being detected in the geographical location of the most severely injured areas each year.

Potatoes

Commencing in 1977 the degree and extent of upper and lower surface oxidant injury to potato foliage was assessed throughout the major production areas of southern Ontario.

The foliar symptoms on this crop usually appear sometime between late June to mid-July when the plants have flowered and the tubers are

developing. As the demands for photosynthetically produced nutrition at this time are at their peak the potential for adverse yield effects is great. The symptoms appear either as a blackened stipple or flecking on the upper leaf surface which can coalesce and become bifacial necrotic lesions or as undersurface, irregularly sized, silver-grey lesions which also can become bifacial as they increse in size and severity. The lower surface symptoms very closely resemble those which have been reported on tomato foliage.

Although no attempt has yet been made to compare the severity from one region or year to another the symptoms have been observed in each year since 1977 and have ranged in severity from none to over 30%. Very noticeable varietal differences have been observed and appear to fit well with previously published sensitivity listings.

Tobacco

'Weather fleck' of tobacco has long been recognized as an ozone induced disorder which affects certain susceptible tobacco varieties. The symptoms appear on fully expanded leaves, the younger and older leaves being more resistant. They start on the upper leaf surface as a greyish, water soaked lesion which becomes light ivory to tan-brown in colour with time. In more severe episodes the lesions can coalesce into larger flecks or spots and become bifacial with increasing severity. Successive episodes of ozone fumigation result in new lesions appearing on healthy tissues of recently injured, fully expanded leaves as well as on fully expanded leaves higher on the main stem.

The assessment survey of commercially produced flue-cured and burley tobacco which was conducted only in 1977 was designed to provide information on the severity of the damage throughout the major tobacco production areas. Briefly, the injury was found to range from less than 1% to 20% on flue-cured species and up to 8% on burley types. The most severely affected areas were centered around Leamington and in the St. Thomas and Port Rowan areas.

__Muck Crops__

In 1977 vegetable crops including carrots, celery, lettuce, onions and radish were examined for foliar ozone injury several times from June through August.

In all cases ozone injury to the various species was trace in severity and appeared more pronounced during the later part of the growing season.

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APPENDIX

APPENDIX 1

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ASSESSMENT OF OZONE INJURY TO WHITE BEANS IN SOUTHERN ONTARIO: 1971-1982

The bronzing or rusting of the foliage of white beans has been observed since as early as 1918 and was originally classed as a non-parasitic disease and referred to as sunscald[3]. In 1961 the disorder was reported[1] throughout southwestern Ontario and the resultant defoliation and pod abortion was estimated to have resulted in a loss of approximately 600 pounds per acre of beans in severely affected fields. In 1968, following extensive field work in 1965 and 1967 the symptomology of the disease was more thoroughly documented and the disorder was found to be associated with occurrence of elevated levels of atmospheric ozone pollution[3]. The symptoms were described as follows:

> *"The symptoms first appear sometime between flowering and normal senescence. The older leaves become senescent and abscise prematurely; the younger, fully expanded leaves develop a bronze-coloured necrotic stipple which is confined to the upper surface of the lamina. The stipple may occur in combination with chlorotic symptoms as well. Immature leaves are generally not affected. The developing bean pods may show striate, necrotic lesions along the fibers of the pod sheath. Reduced seed set, pod yellowing and abscission are also associated with the disorder."*

In southern, central and southwestern Ontario the symptoms usually occur fairly late in the growing season about 2-3 weeks before normal rapid defoliation is expected.

Methods

Phytotoxicology investigations began in 1970 when staff accompanied Ontario Ministry of Agriculture and Food (OMAF) as well as Canada Department of Agriculture (CDA) personnel on the white bean disease survey which had been conducted annually throughout the bean growing areas of Kent, Elgin, Lambton, Perth, and Huron counties. In 1971 when the OMAF-CDA disease survey was discontinued and in each succeeding year since that time an annual visit was made by Phytotoxicology Section personnel to assess and compare the injury development in the major bean production areas. From 1971-75 the individual surveys consisted of the random selection and examination of white bean fields located throughout the three major production areas of Kent-Elgin, Lambton-Middlesex-Oxford and Perth-Huron-Bruce. In each case, the examination consisted of a survey of the field and the assignment of an injury category on the basis of the following injury criteria:

- ***Trace*** - *scattered upper surface stippling over a few leaves per plant*
- ***Light*** - *general upper surface stippling of several leaves per plant*
- ***Moderate*** - *general stippling of many leaves with occasional coalescence to flecks*
- ***Severe*** - *majority of leaves on the plant exhibiting severe stippling and flecking accompanied by chlorosis and premature defoliation.*

In 1976 and 1977 the survey technique was altered slightly to provide replicated observations at each site and to generate more information on secondary factors which could alter the response of the crop to ambient ozone levels. The rating system also was ammended to provide a more comprehensive numerical assessment of symptom severity. Injury was assigned a numerical rating from 0 to 6. For comparative purposes, the corresponding injury categories (i.e. trace, light, etc.) which were used during the period from 1971-75 also are shown.

Numerical Rating	Symptom Description	Former Injury Category
0	no symptoms observed	none
1	scattered stippling of a few of the oldest leaves	trace
2	scattered stippling over most of the leaves	
3	scattered stippling over most of the leaves plus moderate stippling or bronzing over a few of the leaves	light
4	moderate stippling or bronzing over most of the leaves with some coalescense into flecks	moderate
5	severe stippling or bronzing coalescing into necrotic flecks on many of the leaves; some premature leaf senescence and initial defoliation	severe
6	severe stippling or bronzing and coalesence on almost all leaves; plants prematurely senescent and defoliation occurring	severe

In 1976 and 1977 additional information on parameters known to affect plant response to ozone were obtained at each site. Each grower was contacted and information was obtained on the planting date and variety grown. In addition, replicated samples of root tissue were collected at each site and were returned to the Phytotoxicology laboratory for the identification of root rot organisms and the assignment of a rot severity index based on the degree of tissue discoloration as shown below.

Root Rot Index	*Description of Rot Severity*
1	*none (healthy)*
2	*trace (up to 10% discoloration)*
3	*light (11-25% discoloration)*
4	*moderate (26-50% discoloration)*
5	*severe (> 50% discoloration)*

In 1977 plant maturity also was evaluated and numerically categorized on a replicated basis corresponding to the observations on bronzing severity. A complete description of the index values is shown below:

Maturity Index	*Description of Plant Development*
1	*plant foliage completely green; most pods quite thin with beginning of bean development; flowers still evident and numerous 1-2 cm developing pods*

2	*plant foliage completely green; most pods are quite thin with initial stage of bean development; no flowers remaining but still numerous immature pods (no beans)*
3	*plant foliage mostly green with some gradual chlorotic development, pods green with oldest ones almost to full size; youngest pods have bean formation but are still quite thin*
4	*plant foliage approximately 50% chlorotic; older pods starting to turn yellow; youngest pods still green but have beans that are approximately 50% developed*
5	*most leaves chlorotic with only a green hue to the plants; most pods have turned yellow and have indented between the beans; still some fully developed green pods at the top*
6	*leaves beginning to abscise - mostly yellow; pods yellow in colour and leathery in texture; bean development mostly complete but beans still soft textured*
7	*leaves have almost totally abscised; pods yellow and dry with completely dry and mature beans (pods rattle when shaken)*

Results

A summary of the results of visual assessment for bronzing severity in each of the 12 years is shown in Table 1. For comparative purposes an index of bronzing severity was developed and also is shown in Table 1. This index was devised by allocating a weighting factor to each of the four bronzing severity categories as follows: trace: 5; light: 25; moderate: 50; and severe: 100. In each year these values were multiplied by the corresponding injury percentile (decimal) and the separate indicies were added to generate the total index value for the year.

From Table 2 it is apparent that bronzing was most severe in 1976 and least severe in 1972 and 71. Injury in the last 2 years (1981 and 1982) has been categorized as light in severity.

During each of the survey years the investigators attempted to

provide information on the pattern of injury development and severity throughout the three main production areas. However, these observations were at best tenuous because of the complicating effects of factors such as plant maturity and edaphic stress on symptom expression. As a result no consistent or conclusive evidence was produced to indicate that one area was being affected more severely than any other. In 1976 and 1977 the more detailed information which was gathered permitted an in depth statistical analysis of these and other factors involved in the symptom complex. Specifically the following questions were addressed:

1. *Are there any differences in varietal response to bronzing?*

2. *Are some areas more severely affected than others?*

3. *Is there any relationship between symptom severity and age of the bean plants?*

4. *Is there a better indicator of plant maturity than chronological age as it relates to bronzing severity?*

5. *Is there any relationship between the severity of root rot invasion and bronzing severity?*

The correlation coefficients and F test analyses for the various comparisons which were made for the years 1976 and 1977 are shown in tables 3 and 4, respectively.

On the basis of these comparisons the following conclusions can be drawn based on statistical significance at the 95% probability level:

1. *In both years bronzing severity was positively correlated with the chronological age of the plants. This relationship was more pronounced in 1976 a year of severe foliar bronzing, than in 1977 when only light bronzing was observed.*

2. *The use of a numerical maturity index in 1977 yielded a better correlation with bronzing severity than the use of chronological plant age; the only cases where plant maturity did not correlate with bronzing severity were fields in Kent-Elgin (all varieties) and with the Sanilac variety (all locations).*

3. *Root rot involving invasion of the main roots primarily by Fusarium oxysporium, Fusarium solani, Rhizoctonia solani and Pythum spp. was more pronounced in 1976 than in 1977 and was positively correlated with the degree of bronzing severity in 1976. This relationship was most apparent in Kent-Elgin and Lambton Middlesex-Oxford counties.*

4. *In neither year was any significant difference in bronzing severity detected between the three main production areas. When the data were adjusted to negate any effect due to plant age or maturity, the results remained non-significant.*

5. *In 1976 a comparison of bronzing severity between varieties revealed a significant difference with Kentwood demonstrating the most injury and Sanilac the least; however this effect was subsequently found to be due to differences in plant maturity and was not a true varietal response.*

Another factor which was examined upon completion of the 8 years of injury assessment was the relationship between bronzing severity and ambient ozone concentration. According to work by Haas[2] white beans become sensitive to ozone approximately 10-11 days after full bloom or 59 days after emergence. Based on the planting date data which were provided in 1976 and 1977 the period of maximum sensitivity in southwestern Ontario would run from about the first week in August through to the third week in

August when the surveys were conducted. Unfortunately, ozone monitoring by the chemiluminiscence method was not initiated until 1974 and then only at the major urban locations including Windsor, Sarnia and London. As such, valid comparisons from 1971 through 1978 cannot be made. However, in one case (Windsor) where the data from 1974 through 1978 (Figs. 1 to 5) were, in most years complete, a few general trends are apparent. In 1974, 1975 and 1977 when only a light or moderate amount of bronzing was detected, the ozone levels during the period of maximum foliar sensitivity generally were below 80-90 ppb and on only one or two brief occasions exceeded 100 ppb. In contrast, a significant ozone episode with levels well in excess of 100 ppb for several consecutive hours was recorded from August 18-22 during 1976, a year of severe foliar bronzing. Although the data are not as complete at the other monitoring stations during these years there is, nevertheless, a similar trend. In 1978 a year of very light bronzing incidence, the expected relationship with ambient ozone levels does not fit, as in that year several ozone episodes with concentrations in excess of 100 ppb were recorded (Fig. 5). Additional monitoring in rural areas of Huron and Lambton counties (Figs. 6 & 7) in 1978 confirmed the presence of several potentially injurious ozone episodes throughout the bean growing areas. The only apparent explanation for the failure of the crop to respond to these levels was the fact that in 1978 the plants were under severe drought stress during that period.

Summary

The annual assessment of ozone injury to white beans throughout the major bean growing areas of southern Ontario which has been conducted by Phytotoxicology Section personnel from 1971-1978 revealed noticeable differences in bronzing severity from one year to another with the most severe injury being detected in 1976. In most years, injury severity was attributed to ozone episodes during the first 3 weeks of August, the time of maximum foliar sensitivity. However, it was apparent that the reaction of the crop to potentially injurious ozone episodes is governed by other factors

with drought stress appearing to have a significant protective effect. The more detailed investigations of 1976 and 1977 revealed several other aspects of the bronzing syndrome on the white bean crop which have been summarized below:

1. *the severity of bronzing was directly related to the chronological age and physiological development of the plants and coincided with the period of maximum foliar sensitivity during the first 3 weeks of August*

2. *no one production area was more severely affected than any other during the survey years even when adjustments were made for differences in plant age and maturity*

3. *some slight differences in varietal sensitivity were detected but were found to be due to differences in plant age and thus did not represent a true genetic response*

4. *the degree of root rot was found to fluctuate from one year to another and in the more severe case (1976) was associated with more severe foliar bronzing.*

Effect on Production

In spite of the absence of any direct yield reduction data from these annual surveys there is evidence of major shifts in production areas with the trend being towards a decrease in Kent County and a shift to the more northern counties of Huron and Perth. The table below depicts the production shifts which have occurred from the early 1960's to the mid-1970's in these three counties.

Change in White Bean Acreage from 1959-1976 in Three Counties of Ontario

County	Acreage Expressed as a % of the Provincial Total		
	Early 1960's	Mid 1970's	Difference
Kent	37	4	-33
Huron	33	39	+6
Perth	3	18	+15

These production shifts generally have been attributed to the severity of bronzing in the southern counties and the potential for greater yields in the less severely affected northern locations. However, a review of some of the agricultural statistics reveals that bronzing may not have been the entire reason for this shift. Table 5 shows the average yields for the 4 counties expressed as a % of the provincial average in each of six 3-year periods from 1959 to 1976 and also shows the corresponding number of acres grown. An evaluation of these data reveals several interesting phenomena:

1. *Approximately one half of the total reduction in white bean acreage in Kent County occurred from 1959-1970 and corresponded with yields which were, for the most part, above the provincial average.*

2. *In spite of the fact that yields in Elgin County have generally been below the provincial average there has not been any decrease in acreage grown.*

3. *Although bean yields in Huron County were consistently below the provincial average up until 1968, significant acreage increases were experienced during that period.*

On the basis of this information it would appear that the yield of the crop has not totally influenced the growers' decision to increase or decrese their production acreage. These figures complicate the assessment of the effect of bronzing on the shift in bean production as it cannot be simplistically stated that the annual occurrence of the bronzing disorder in Kent and Elgin counties has reduced bean yields resulting in a decrease in crop acreage. Nor is it true that bean production in the more northern counties increased because farmers were able to produce higher yields under bronze-free conditions. There is no doubt that the bronzing syndrome has in many years significantly reduced bean yields and that bronzing has at times been more severe in the southern counties of Kent and Elgin. However, the acreage decrease in Kent County and the corresponding increase in Perth and Huron counties probably was influenced by several other factors. To farmers in the northern counties the potential return per acre with white beans was considerably higher than the customary returns for the more traditional crops of small grains, hay and corn. On the other hand farmers in Kent County have traditionally had more scope in crop choice because of additional heat availability. Crops such as tomatoes, tobacco, coloured beans, sweet corn, and soybeans are all high return crops and probably became more popular as greater difficulty was encountered in the production of white beans. Other factors such as the incidence of root rot and other pathogens in fields that had been growing beans for many years also probably had an effect on the reluctance of many growers to continue with the white bean crop.

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TABLE 1

Annual Severity of Bronzing Injury to White Beans in Southern Ontario 1971-1982

		Injury Percentiles					Severity Index Values**				
Year	No. of Observations	None (0)*	Trace (1)*	Light (2-3)*	Moderate (4)*	Severe (5-6)*	Trace (5)	Light (25)	Moderate (50)	Severe (100)	Total Index Score (100)
1971	21	71	5	14	10	0	.3	3.5	5.0	0	9
1972	43	62	19	9	5	5	1.0	2.3	2.5	5.0	11
1973	50	4	8	32	42	14	.4	8.0	21.0	14.0	43
1974	33	6	15	37	33	9	.8	9.3	16.5	9.0	36
1975	39	8	8	48	18	18	.4	12.0	9.0	18.0	39
1976	54	0	7	19	30	44	.4	4.8	15.0	44.0	64
1977	28	4	14	42	36	4	.7	10.5	18.0	4.0	33
1978	11	9	18	46	27	0	.9	11.5	13.5	0	26
1979	13	0	40	30	30	0	.2	7.5	15.0	0	23
1980	21	0	14	38	33	14	.7	9.5	16.5	14.0	41
1981	17	0	12	65	23	0	0.6	16.3	11.5	0	28
1982	48	2	23	44	27	4	1.2	11.0	13.5	4.0	30

* corresponding numerical injury rating utilized from 1975-82.

** calculated by multiplying injury percentile by assigned numerical value for each injury category and adding the 4 values for a Total Index Score (maximum of 100) (i.e. 15% in trace = 1.5 x 5 = .75).

TABLE 2

Comparison of the Severity of Bronzing Injury to White Beans in Southern Ontario 1971-1982

Year	*Total Index*	*Annual Severity Category*
1976	*64*	*Severe (> 50)*
1973	*43*	
1980	*41*	*Moderate (36-50)*
1975	*39*	
1974	*36*	
1977	*33*	
1982	*30*	*Light (20-35)*
1981	*28*	
1978	*26*	
1979	*23*	
1972	*11*	*Trace (< 20)*
1971	*9*	

TABLE 3

Statistical Analysis of the 1976-77 White Bean Bronzing Data

Comparison	Year	Coefficient of Correlation (r)						
		All Values	Kentwood	Seafarer	Sanilac	Area[a] 1	Area[a] 2	Area[a] 3
Age vs. Bronzing Severity	1976	0.60**	0.47	0.77**	0.27	0.69**	0.29	0.56*
	1977	0.50*	0.76	0.34	0.56	0.75*	0.67	0.21
Plant Maturity vs. Bronzing Severity	1976	-	-	-	-	-	-	-
	1977	0.76**	0.96**	0.72**	0.58	0.88**	0.72*	0.21
Root Rot Severity vs. Bronzing Severity	1976	0.34*	0.47	0.31	0.21	0.50*	0.49*	0.45
	1977	0.31	0.53	0.45	-0.01	0.43	0.41	- 0.13

* Statistically significant at the 95% level of probability
** Statistically significant at the 99% level of probability

[a] Area 1 - Kent-Elgin
Area 2 - Lambton-Middlesex-Oxford
Area 3 - Huron-Perth-Bruce

TABLE 4

Statistical Analysis of the 1976-77 White Bean Bronzing Data

Comparison	Year	F Test Value	
Analysis of Variance between Areas	1976	0.92	
	1977	0.06	
Analysis of Covariance between Areas (adjusted for plant age)	1976	0.83	
	1977	0.76	
Analysis of Covariance between Areas (adjusted for plant maturity)	1976	-	
	1977	0.44	
Analysis of Variance between Varieties	1976	3.75*	(Kentwood Seafarer, Sanilac)
	1977	0.20	
Analysis of Covariance between Varieties (adjusted for plant age)	1976	0.12	
	1977	0.02	
Analysis of Covariance between Varieties (adjusted for plant maturity)	1976	-	
	1977	0.46	

* *Statistically significant at the 95% level of probability*

TABLE 5

Comparison of Yield and Production Acreage for White Beans in Ontario 1959-76

Years	Average Number of Acres Grown (acres x 1000)				Average Yield as a Percent of Provincial (+ above, - below)			
	Kent	Elgin	Huron	Perth	Kent	Elgin - % -	Huron	Perth
1959-61	24.2	5.7	21.5	1.7	+2.9	-8.6	-1.0	+2.9
1962-64	23.5	6.7	23.0	2.9	+2.2	0	-2.9	+0.7
1965-67	21.3	12.0	38.0	11.0	+11.0	+6.6	-11.0	-1.5
1968-70	12.8	13.1	33.3	10.5	-9.4	-14.1	+13.3	+4.7
1971-73	6.5	12.4	49.9	17.3	+0.7	-9.6	+5.5	+4.8
1974-76	5.2	12.0	58.5	27.5	-16.4	-18.9	+7.4	+8.2

FIGURE 1

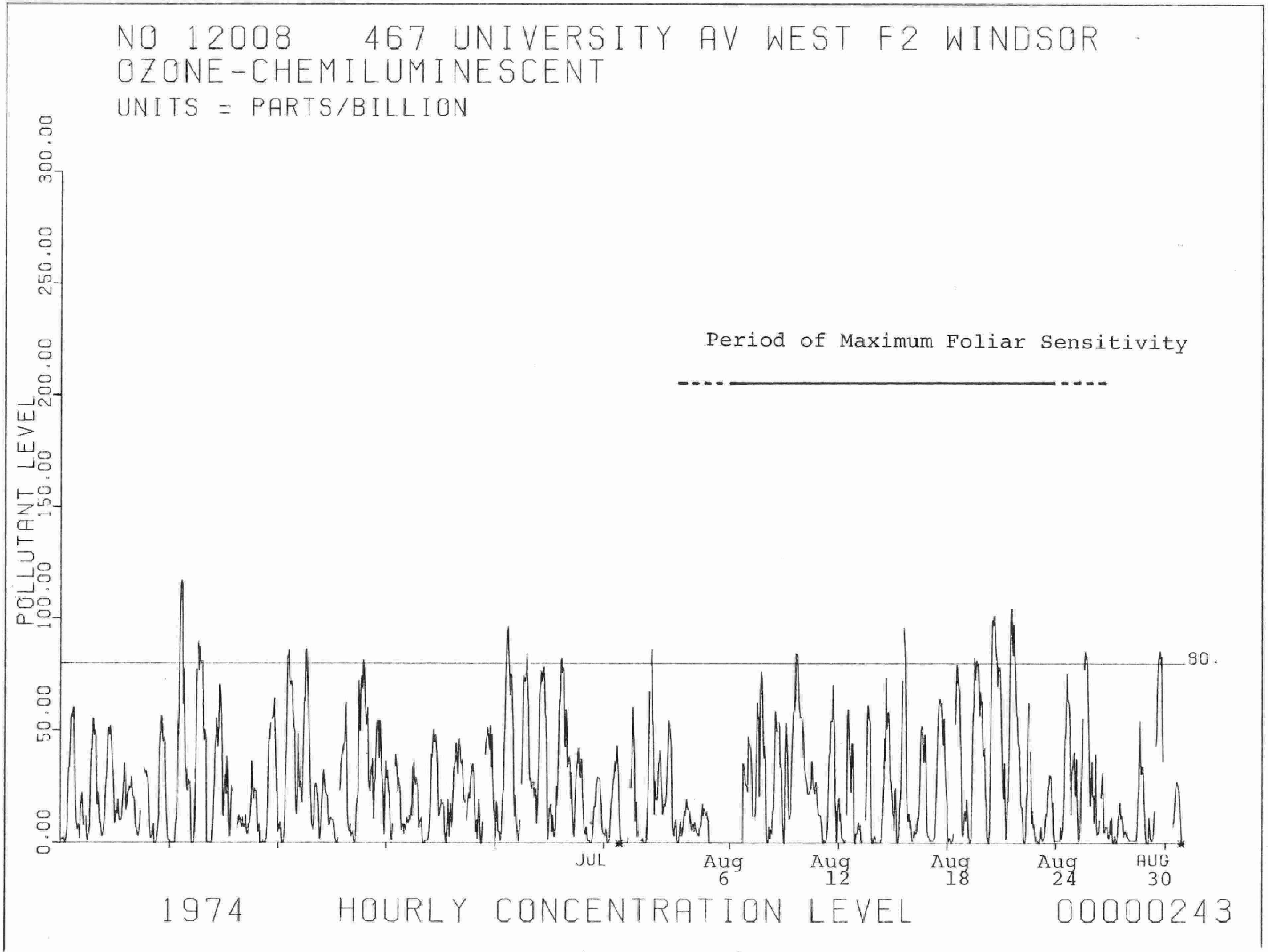
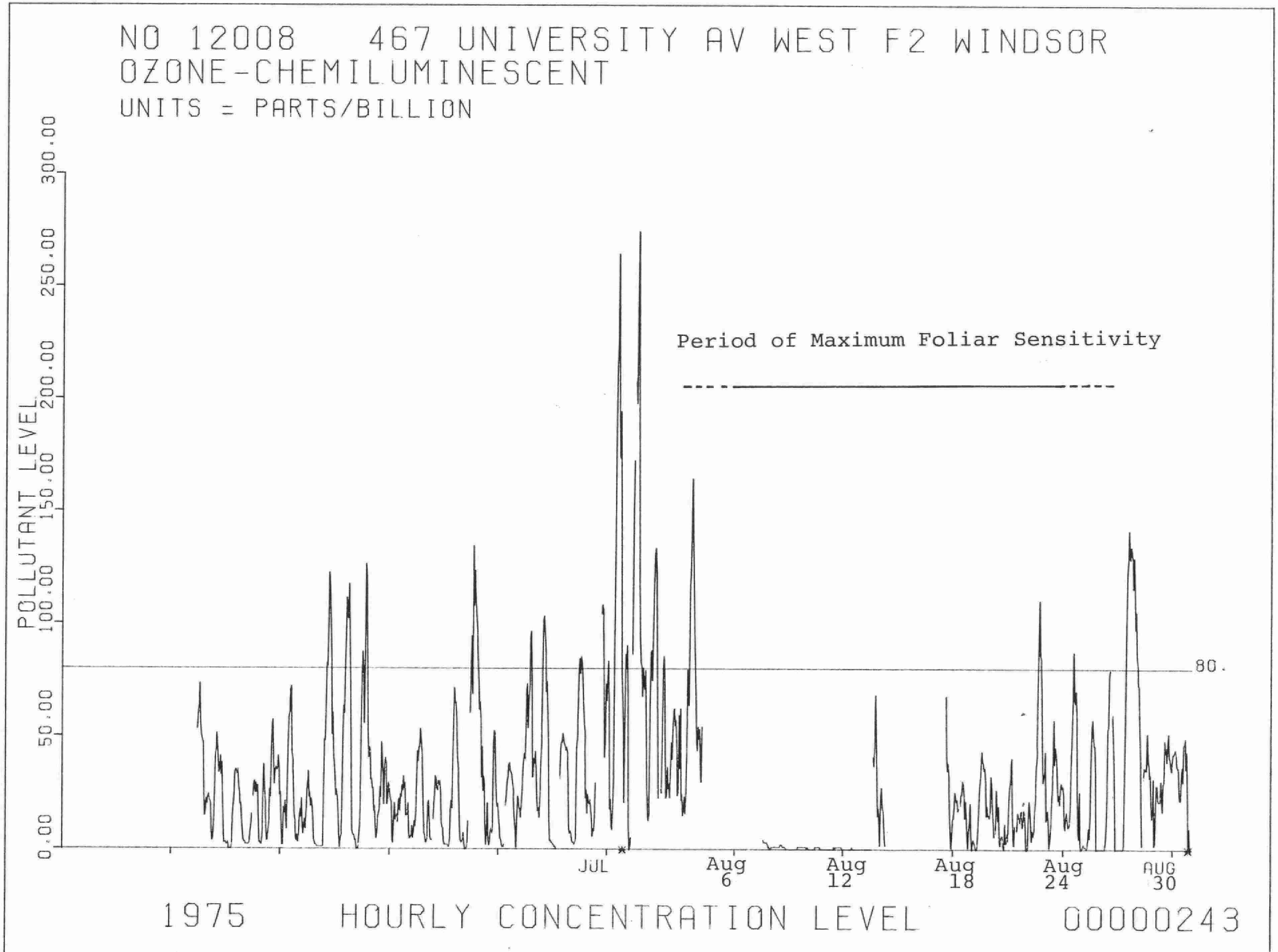

NO 12008 467 UNIVERSITY AV WEST F2 WINDSOR
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
POLLUTANT LEVEL
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Period of Maximum Foliar Sensitivity
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1974 HOURLY CONCENTRATION LEVEL 00000243

FIGURE 2



NO 12008 467 UNIVERSITY AV WEST F2 WINDSOR
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
POLLUTANT LEVEL
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Period of Maximum Foliar Sensitivity
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1975 HOURLY CONCENTRATION LEVEL 00000243

FIGURE 3

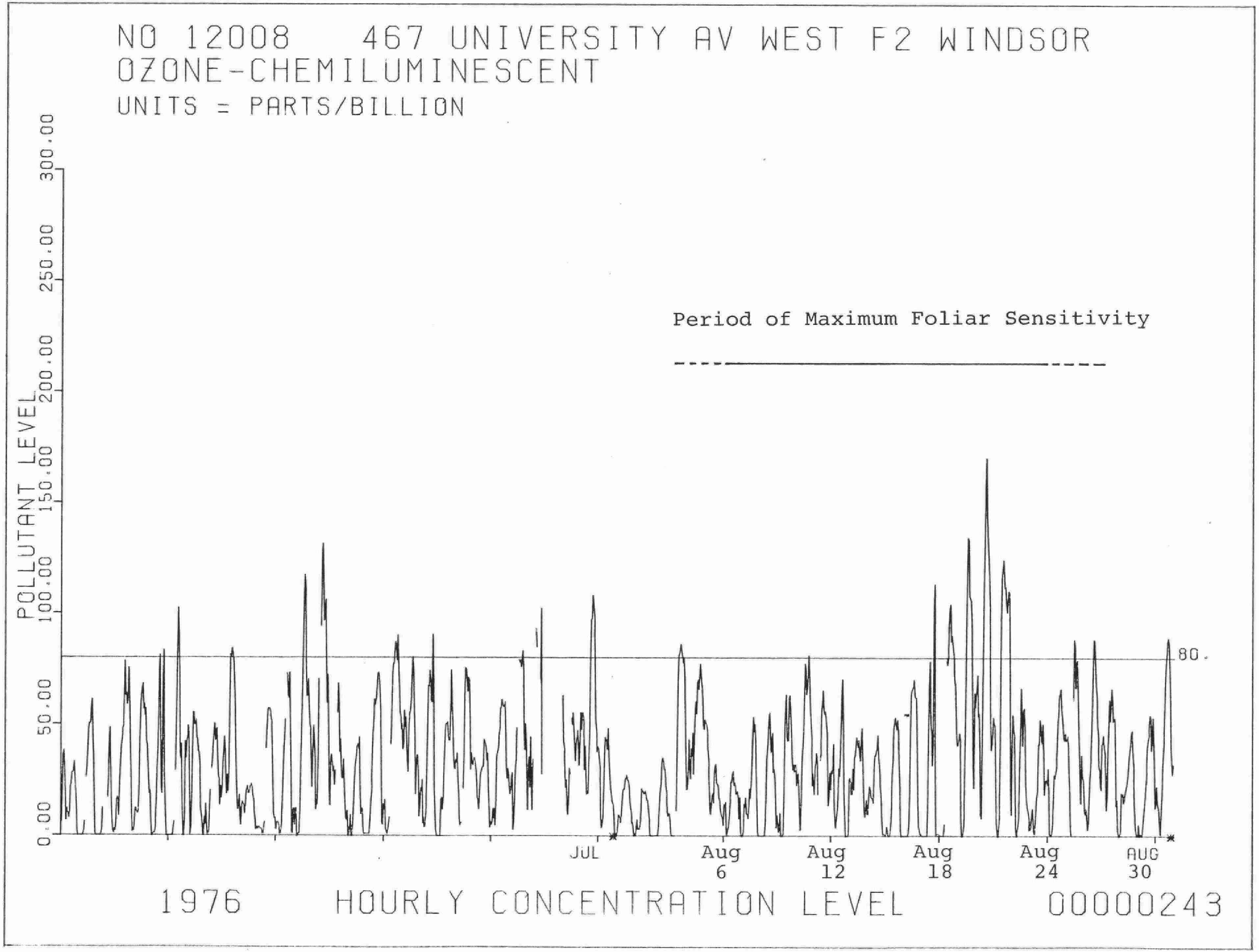
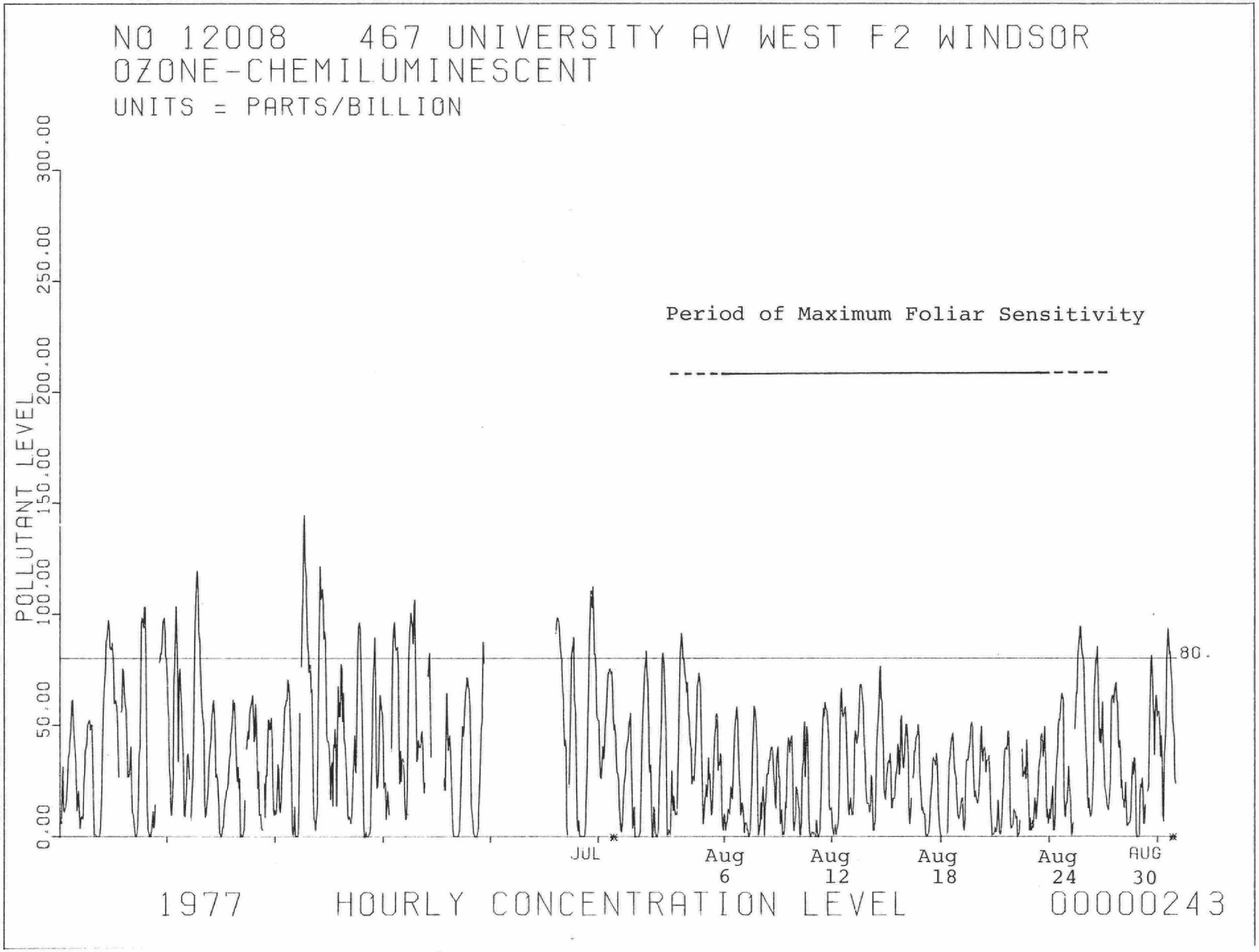

NO 12008 467 UNIVERSITY AV WEST F2 WINDSOR
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
POLLUTANT LEVEL
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Period of Maximum Foliar Sensitivity
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1976 HOURLY CONCENTRATION LEVEL 00000243

FIGURE 4



NO 12008 467 UNIVERSITY AV WEST F2 WINDSOR
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
POLLUTANT LEVEL
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Period of Maximum Foliar Sensitivity
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1977 HOURLY CONCENTRATION LEVEL 00000243

FIGURE 5

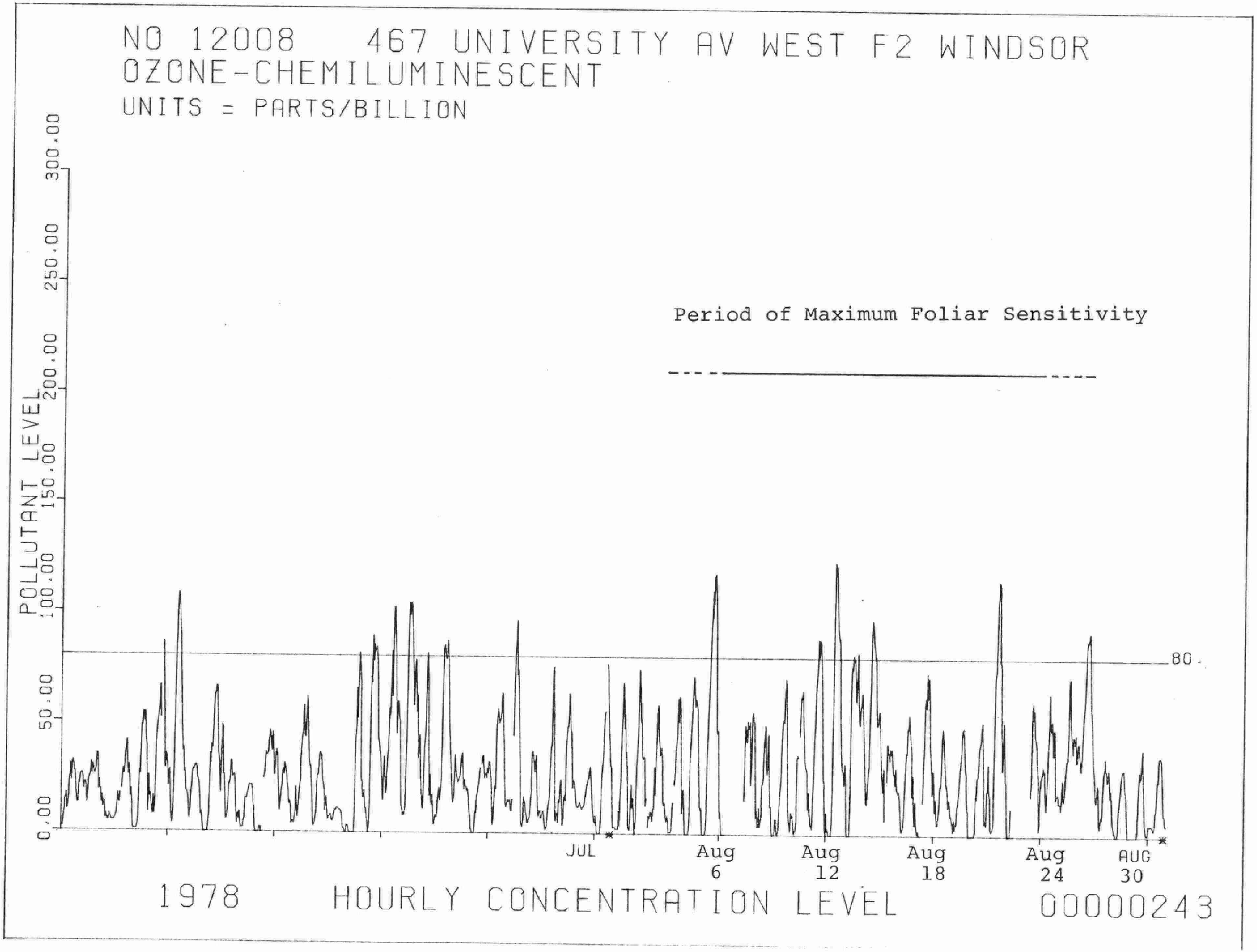
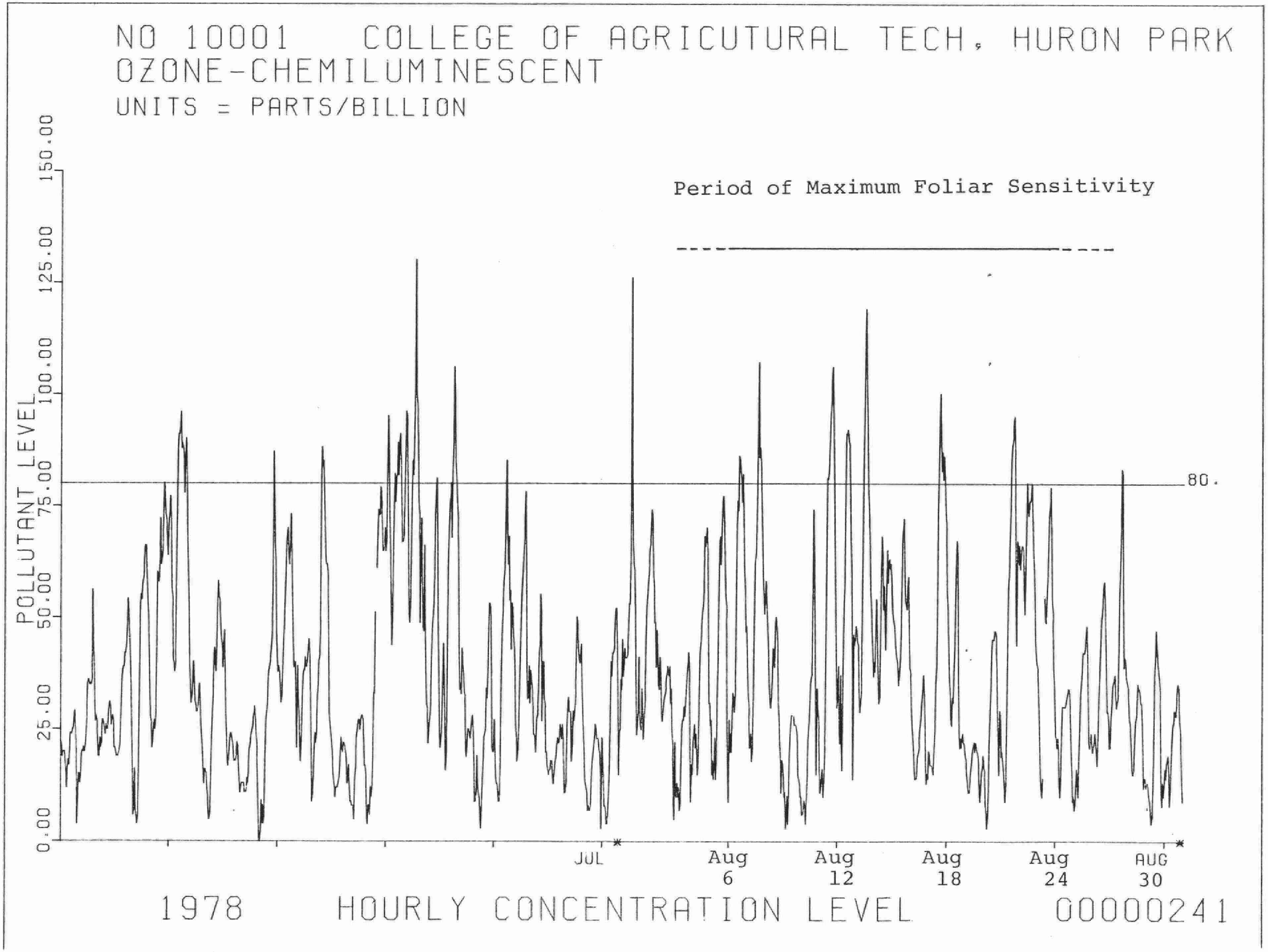
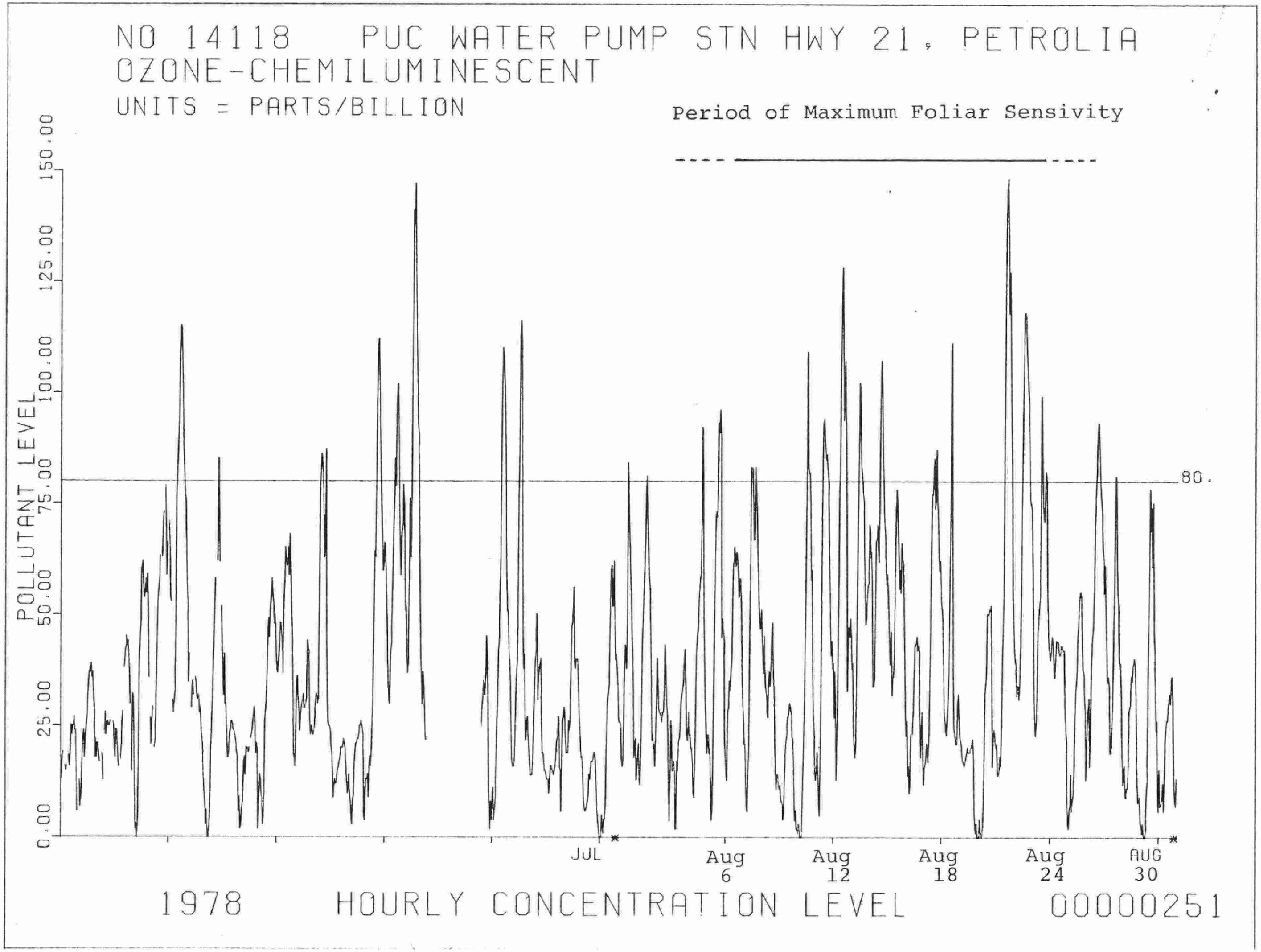

NO 12008 467 UNIVERSITY AV WEST F2 WINDSOR
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
POLLUTANT LEVEL
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Period of Maximum Foliar Sensitivity
80
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1978 HOURLY CONCENTRATION LEVEL 00000243

FIGURE 6



NO 10001 COLLEGE OF AGRICUTURAL TECH, HURON PARK
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
Period of Maximum Foliar Sensitivity
POLLUTANT LEVEL
0.00
25.00
50.00
75.00
100.00
125.00
150.00
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1978 HOURLY CONCENTRATION LEVEL 00000241

FIGURE 7


NO 14118 PUC WATER PUMP STN HWY 21, PETROLIA
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION
Period of Maximum Foliar Sensivity
POLLUTANT LEVEL
0.00
25.00
50.00
75.00
100.00
125.00
150.00
80.
JUL
Aug 6
Aug 12
Aug 18
Aug 24
AUG 30
1978 HOURLY CONCENTRATION LEVEL 00000251

APPENDIX 2

Ontario

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ASSESSMENT OF PAN-TYPE INJURY TO TOMATO CROPS IN SOUTHERN ONTARIO: 1974

INTRODUCTION

PAN (peroxyacetyl nitrate)-type injury has been encountered in S.W. Ontario during 1972 and 1973. The occurrence of this injury during two consecutive years suggests that this may be a continuing problem on the tomato crop of S.W. Ontario. The purpose of this survey was to determine the extent and severity of PAN-type injury occurring on the 1974 Ontario tomato crop. Annual surveys, it is hoped, will give some insight as to the possible seriousness of this pollutant in Ontario.

FORMAT OF SURVEY

Observations were made by Messrs. R.G. Pearson and D.B. Drummond on June 25, 26 and 27, 1974. Additional observations were made prior to the above dates on May 29 and June 24 in conjunction with other studies. To ensure that as much of the tomato crop could be visited as possible, Messrs. Pearson and Drummond surveyed different areas, making joint observations only at the Simcoe Horticultural Research Station. An area from Harrow in the SW through the Niagara Peninsula was covered during this surveillance. A route from London through Tillsonburg and on to Simcoe was traversed; however, no tomatoes were found between these lcoations. All of the tomato fields in this part of Ontario seemed to be lcoated close to the north shore of Lake Erie.

RESULTS

The results of the June 25 through 27 survey can be seen in Table 1. Each field represents a separate entry in the table. The location of each field observed also can be seen in Figure 1.

Figure 2 shows the locations where PAN-type injury was encountered. The severity of the injury also is shown. It can be seen that the injury was fairly close to the north shore of Lake Erie, ranging from Harrow through and almost to Simcoe and that, in general, the severity was not great.

The injury west of London was observed on cultivars Veemore and H-1409. From the previous year's observation these varieties are known to be among the most sensitive. Observations along the north shore of Lake Erie to the east of London indicated that there was light to moderate injury on cultivar H-1350 and trace to light injury on Campbell 28. Trace to moderate injury also was observed on several cultivars at Burlington, Ontario. Observations by Mr. R.G. Pearson on May 29, 1974, (not found in Table 1), suggest that trace injury was present to the west of Harrow. Observations made by the undersigned on June 24, 1974, revealed PAN-like symptoms on cultivar Veemore northeast of the Metropolitan-Toronto area.

A sample was collected by Mr. R.G. Pearson (387) for Pathology Analysis from the Burlington area. The results of this analysis indicate that neither fungi nor bacteria were the cause of upper surface bronzing that was observed. Histological examination of the same sample revealed that the injury was to both the palisade and spongy mesophyll regions. However, generally there was more injury to the lower surface than the upper cellular regions. This injury was consistant with injury caused by PAN. The undersigned collected a sample of suspected sun-scald injury at the Harrow Research Station (Sample #6041). Histological examination revealed that only the bottom two layers of cells were affected and that these layers were

completely flattened for a rather extensive area. This suggests that the causal agent was external to the leaf. The sun-scald injury observed at several locations on the survey was similar, in some respects, to PAN-type injury. However, a shading effect could usually be detected and the normal pattern of PAN-type injury was not noted.

CONCLUSIONS

It can be concluded from the observations made during the survey conducted in 1974 that the severity is substantially less than that observed in either 1972 or 1973. These conclusions are based on; (1) only the most sensitive varieties were injured at most of the locations; (2) the severity of the injury to the plants observed was, in general, greatly reduced over that observed in previous years; and (3) the number of locations where injury was encountered was reduced when compared to the previous two summers.

The area of greatest severity was adjacent to the north shore of Lake Erie, between Long Point and St. Thomas. Moderate injury was observed on cultivar H-1350, a variety frequently observed throughout this survey, usually showing no injury. The injury was consistent from one field to another in this small area of the Province.

The 1974 survey provided a unique opportunity to compare injury incited from a suspected PAN exposure and injury incited by exposure to sunlight. Differences indicate that sun-scald injury and PAN-type injury can be relatively easily distinguished under field observations.

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DBD/hm

Attach.

PH/35/4

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height		Symptoms & Severity
1	Intersection Hwy 76 & 401, SE corner	C 1327	(30)+	
		H 1350	(20-25)	NONE
		Fireball	(30)	
		Early bird	(30)	
2	1.9 miles W of New Glasgow on Hwy 3	Starfire	(30)	
		Early bird	(30)	NONE
3	6.6 miles W of New Glasgow	C28	(20)	
		H 1350	(20)	NONE
		H 1630	(20-25)	
		H 1409	(20)	L injury on 10-20% of Pl. Oldest 2 or 3 lvs affected
4	Ridgetown College	Bonny Best	(25)	
		Early bird	(20-25)	
		Scotia	(20-25)	
		714(planting #005	(25)	
		713(planting #004	(25)	
		724(planting #1003)	(25)	NONE
		C36	(25)	
		H1350	(20)	
		Veebrite	(20)	
		H1630	(20)	
		C28		
		Veemore(20)1st rep		L-M, all plants
		ST21	(25)	
		Veemore(20)2nd rep		M, all plants
		Starfire	(20)	
		Spring Set	(25)	
				No injury on any variety except Veemore which had light to moderate injury on all plants. Note: the same variety is being used by the Phytotoxicolog Section in the NE Toronto oxidant study. In the 2nd replication plot all plant were moderately injured.

* Corresponds to locations shown in Figure 1

\+ number in parenthesis represents plant height in centimeters

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height	Symptoms & Severity
5	1 mile W of Maple City (1 mile N of 401 intersection with #12)	Unknown; could be H1350(30)	NONE
6	N of Hwy 401, halfway between Ridgetown and Chatham. Planting trials no longer here	C28 (20)	NONE
7	4.8 miles S Hwy 40 & 401 intersection	H1350 (15) C28 (15)	NONE
8	Halfway between Leamington and Wheatley	C28 (35)	NONE (one plant had leaf inverted by the wind and showed a silvery pattern on the undersurface. However, a shadow effect was noticeable in the veinal areas where the raised veins shaded portions of the leaf; it was uninjured in these areas)
9	West fringe of Leamington	C28 (30)	NONE
10	4 miles SE of Leamington on Concession Road "B" - farm of Mr. Melrich	H1409 (15)	L-M (Overall correspondence to the typical pattern was not good - most of the leaves adjacent to the ground were uniformly injured and leaves furthe up the plant were not injured as severely, if at all. This lack of correlation to the typical symptom development pattern may have bee due to the age of the plant since they are quit small
11	5 miles W of Leamington - the H. Winter residence	Spring Set (20) Early Bird (25)	NONE
12	6 miles E of Kent County Line (Stop made last year as well)	1350 (30) 1630 (30)	NONE

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height	Symptoms & Severity
13	1st field on right after Kent Road 14 & Hwy 3	1630 (15) C28 (15) 1409 (15)	NONE NONE L on oldest leaves (Some sun scald on leaves that had been turned over and exposed to the sun)
14	2 miles W of Chatham	Unknown (15)	NONE
15	SW edge of Chatham	Unknown (20)	NONE
16	Intersection 401 & 77, NE corner	Unknown (15-18)	NONE (this is the field where last year severe bronzing occurred on 1409)
17	5 miles N of Leamington	Unknown (15)	NONE
18	N city line of Leamington	Celery	NONE
19	Harrow - Canadian Agricultural Research Station	Springset (early variety(40) Veebrite (15) H1630 Veemore(15)1 repl'n Veemore(20)3 repl'n C28 (20) 1350 (20)	NONE
20	S of 401 on a road parallel to that Hwy about 4 miles to W of Woodslee	H1350 (15)	NONE (some undersurface silvering on leaves that demonstrated severe aphid attack)
21	3.4 miles E of intersection Hwy 2 and Essex 27 (or 1mile E of intersection of Hwy 2 and Essex County Road 47)	1350 (20-25)	NONE
22	2.9 miles E of intersection Essex 31 and Essex County Road 2	1350 (15-20) Ottawa (15-20)	no PAN injury (mechanical injury from wind etc)
23	approx 5 miles E of last stop	1350 (15)	No PAN symptoms- wind injury
24	1.5 miles W of bridge crossing Thames River just W of Chatham	1350 (20-25) 1409 (20)	No PAN injury; some mechanical injury on lower leaves

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height	Symptoms & Severity
25	Hwy 40 N of Chatham; field is on W, one concession road N of road to Dover Centre	1350 (15) 1370 (15)	No PAN symptoms; fair amount of mechanical injury from windblown material on the oldest v. small leaves
26	5.2 miles E of Base Line Road & Hwy 40 intersection	1350 (15) 1370 (15)	No PAN injury - some mechanical injury
27	outside the town of Tupperville	1350 (25-30)	Uniform very light silvering on undersurface of most of the leaves - however the grower indicated that they had been spraying earlier in the morning - this is the most probable cause of this occurrence. This particular individual grows about 12 million plants for Canadian Canning Co out of Dresden
28	Intersection of 15th Concession approx 1 mile W of Hwy 40, directly S of Wallaceburg, approx 7.8 mi	1630 (15) C28 (15) 1409 (15)	NONE
29	Dresden, Ont, Del Monte Cannery; talked with Mr. Jim Dick, their representative who first reported PAN injury 2 years ago	1350(several repl'n Veeroma & several others	No PAN-like injury
30	Hwy Elgin County Road to SE of St. Thomas - a small garden adjacent to the woods, no apparent owner - a tomato row or two	Unknown (30)	No PAN-like symptoms - some insect activity
31	2.2 miles S of intersection in Sparta on 36 - a garden	Bonny Best (25) Starfire 1 (25) Early Bird (25)	L PAN injury on 3rd and 4th leaf down from the top; the pattern is definitely that of PAN; 3rd leaf showing injury all the way down to the basal leaflets. In addition these plants seem to be rather severely hit by insect activity with chewing activity on the lower leaves.

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height	Symptoms & Severity
32	SE corner of the intersection of Elgin Rd. 36 & 24	C28 (15-25)	M; 1 plant out of about 15 demonstrated moderate PAN-like symptoms. Spray drift from an adjacent corn field caused injury on a few plants further down the field.
33	N of Port Burwell - at the J. Well & Sons Fruit Farm	1350 (15) Spring Set	T-L* NONE[x] *On the smaller plants of the 1350 there was trace to light PAN injury Most of the plants were uninjured - these were larger. Plants with injury were about 15 cms. The Spring Set were [x]located at the back of the farm - on a slight rise so they were in good exposure - no symptoms.
34	8.3 miles E of Norfolk County Line - a field of tomatoes on N side of road growing on heavy soil	Unknown (15)	NONE
35	3 miles further E	1350 (25)	L-M PAN injury
36	1.1 miles N of intersection of Hwy 59 & Port Rowan	Spring Set (20) 1350 (15-20)	L-M L Spring Set had light to moderate injury on several plants; 1350's had light PAN-like injury
37	6.6 miles from intersection of Hwy 59 & 24 E to Simcoe	C28 (25)	T-L PAN-like injury
38 (see last entry)	Simcoe Horticultural Research Station	Veemore (30) 1350 (25-30) Veebrite (35)	L T L Note: Notes here mostly taken by Ron Pearson
39	4 miles directly S of Horticultural Station and is located on the Mandryk Farm just off Hwy 6	Spring Set (15) Bush Beef-steak (15) Big Boy (15)	T-L on undersurface of leaves NONE - some silvering but possibly sun-scald T

TABLE I Results of a survey conducted on June 25, 26 and 27, 1974 to delineate any PAN injury to the tomato crop of SW Ontario.

Stop Number*	Location	Variety & Height	Symptoms & Severity
40	Field on S edge of Waterford	Spring Set (35-40) Veebrite (35-40) 1327 (35-40)	NONE No injury on any - grower indicated that he got a head start in getting them into the field. It is possible that the plants were too old for injury to occur.
41	Field also on S edge of Waterford	Unknown (20-25)	NONE
42	Farm adjacent to Steeles (a plot owner in Nanticoke study)	Spring Set (30) 1350 (25-30)	L PAN-like injury on both varieties.
(RGP) 43	Burlington, Mr. Trecunno	Mixture of 8 varieties	NONE
(RGP) 44	Burlington, Mr. Thorpe	Jet Star (40-45) Sutton-Earliest of all	NONE M PAN from 7th to 15th leaf (counting from bottom) Herb and Hist. collected. Planted May 1
(RGP) 45	Vineland	V701 (20-25) New Yorker (25-35) Viscount (25-35) Viceroy (35-40) Ont 737 (35-40)	NONE Trace injury NONE NONE NONE
(RGP) 38	Additional varieties for Stop #38	Campbell 28 1630 H1706 H6919 Lafayette Springset	None T NONE NONE L-M L

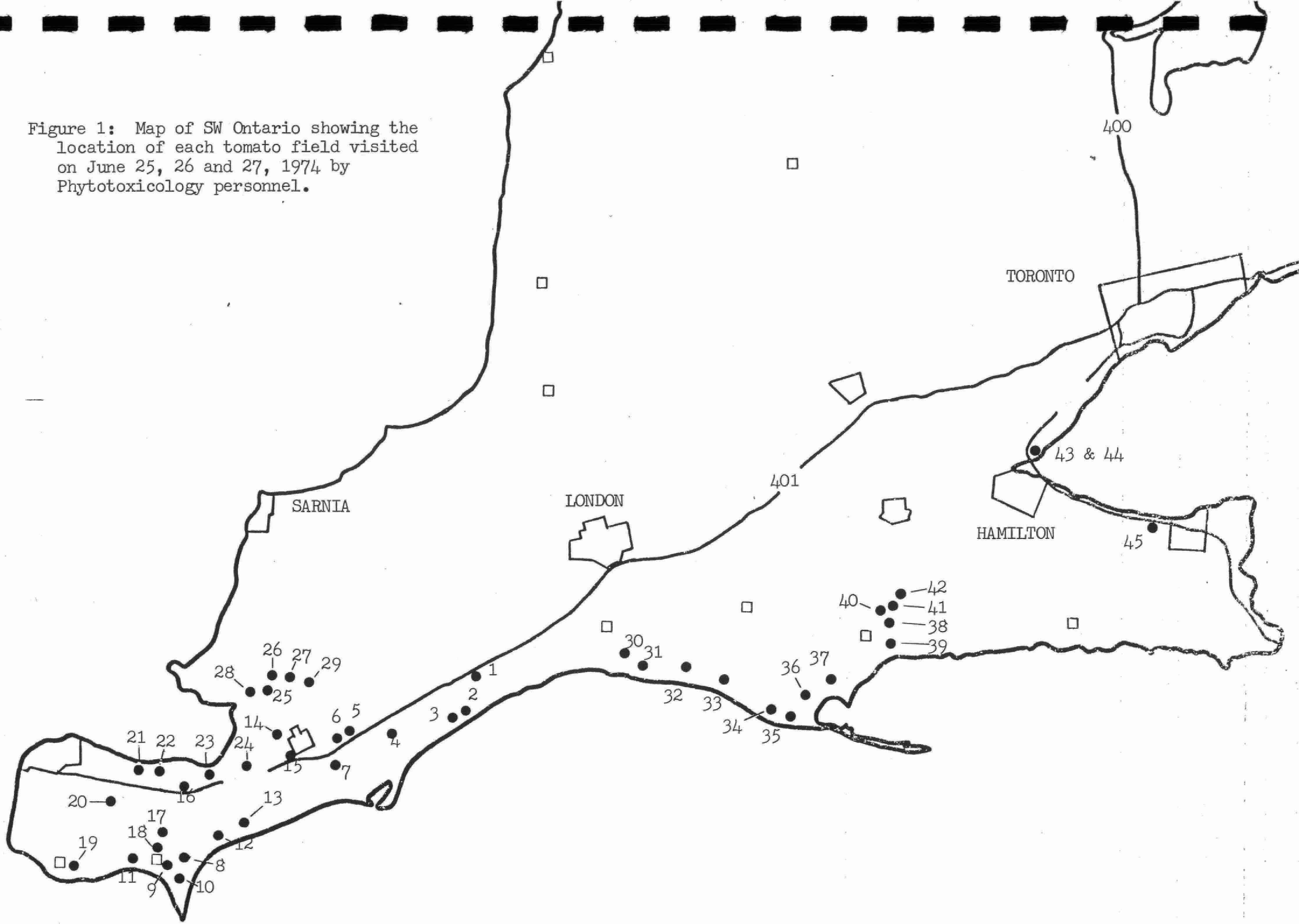
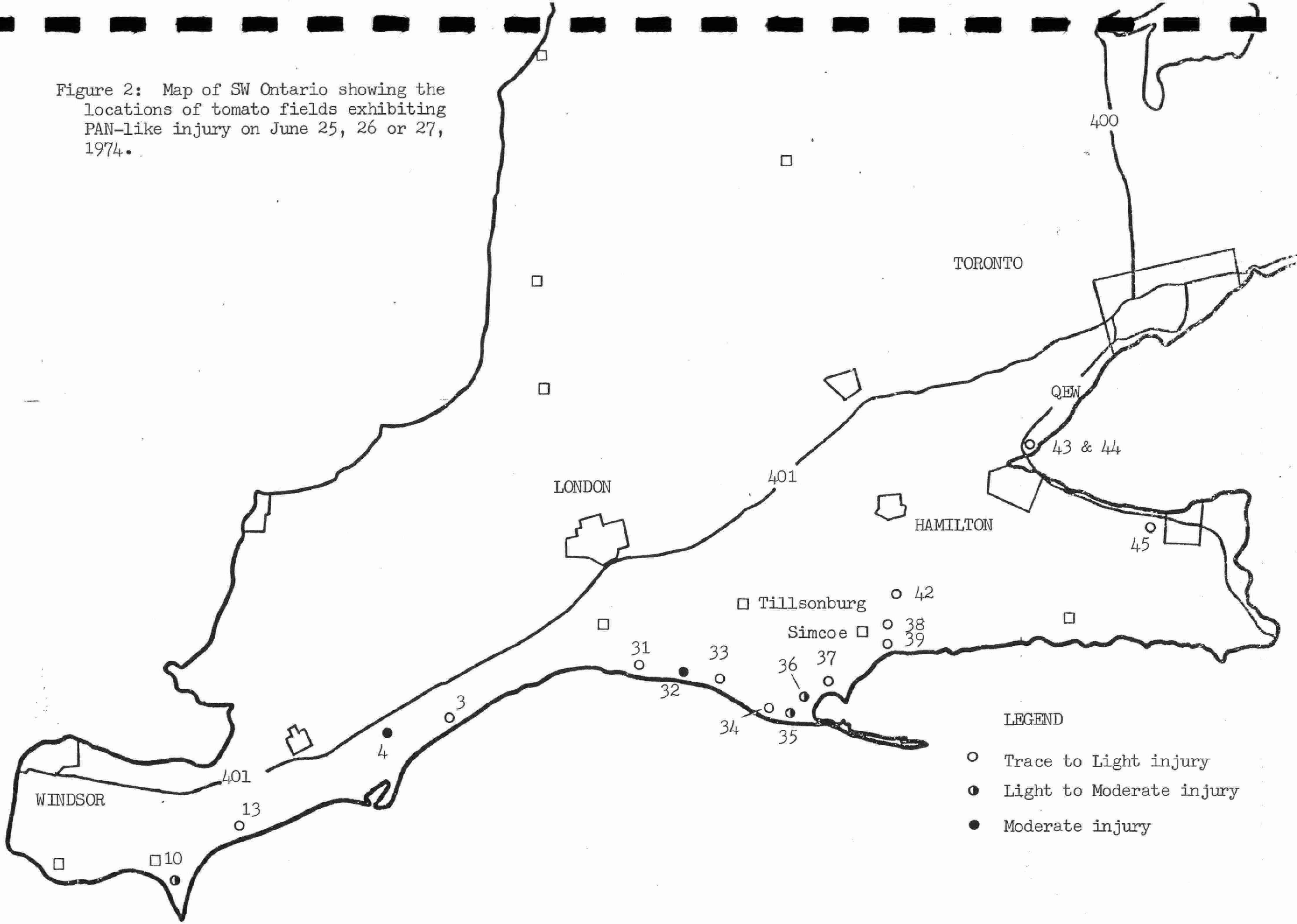


Figure 1: Map of SW Ontario showing the location of each tomato field visited on June 25, 26 and 27, 1974 by Phytotoxicology personnel.

Figure 2: Map of SW Ontario showing the locations of tomato fields exhibiting PAN-like injury on June 25, 26 or 27, 1974.



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Ontario

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Toronto (Ontario)
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ASSESSMENT OF PAN-TYPE INJURY TO TOMATOES IN SOUTHERN ONTARIO: 1975

Introduction

Peroxyacetyl nitrate (PAN)-type injury to tomatoes in Ontario has been noted annually since 1972. Substantial amounts of injury to tomato were found in 1972 and 1973, while during 1974 levels of injury to the tomato crop were greatly reduced. The purpose of the 1975 survey was to provide a continuation of data relevant to the occurrence of this particular pollutant within the boundaries of Ontario.

Format

The format of the 1975 PAN-type injury survey was similar to that conducted during 1974. During the week of June 23-26, 1975, Mr. R.G. Pearson and the author visited tomato-growing areas in S.W. Ontario. The same areas were covered as have been covered in past surveys. At each stop the tomatoes were inspected for the typical under-surface symptoms associated with PAN-type injury.

Varietal differences in susceptibility exist, with previous surveys suggesting that cultivars Veemore and Heinz 1409 are the most sensitive commercial varieties. An effort was made during the 1975 survey to observe these particular cultivars. Veemore is grown on several of the Horticultural Research Stations in the province and Heinz 1409 is contracted by Heinz with several growers across the S.W. counties.

Mr. J. Krushelniski, Agricultural Department of Research, H.J. Heinz Co. Ltd., was contacted and a list of H-1409 growers was obtained. The area covered by the 1975 survey ranged from Windsor on the west through the Niagara Peninsula, along the N. shore of Lake Erie. In addition, tomatoes were observed in the Burlington area and to the N.E. of Toronto.

Results

The results of the June 1975 survey can be seen in Table 1. Each individual entry represents a visit to a particular field or farm. More than one variety may be present at a particular location. The number in the left-hand column of Table 1 is keyed directly to locations shown in Figures 1 and 2. Figure 1 illustrates the locations of all fields visited during the survey, while Figure 2 shows only those fields where PAN-type injury was observed. The severity of injury observed at that location is noted as either trace, light or moderate. It can be seen that trace injury was encountered to the west of London with the exception of field Number 16. In the St. Thomas to Niagara area light injury was observed at several locations. At one location, the Simcoe Horticultural Research Station, moderate injury was observed on Veemore. While 1409 and Veemore were not uniformly found across the region, they were found at locations sufficiently separated so that the data contained in Table 1 represent a fairly accurate picture of the amount and distribution of PAN-type injury during 1975. The amount of injury observed during 1975 was less than that observed during any of the three previous years.

Discussions with many of the tomato growers indicated that the S.W. part of Ontario received substantial rainfall during the spring of 1975. Many farmers indicated that rain occurred almost every day and that long periods of overcast conditions had been present. Much less sunscald injury to young tomatoes was observed in 1975 as compared to 1974. This

observation would help substantiate the presence of long periods of overcast weather during the spring of 1975. This probably contributed to the low level of PAN-type injury observed during 1975.

It is possible that some injury occurred subsequent to our visit to S.W. Ontario. Dr. E. Kerr observed what he thought to be additional injury to tomatoes in some of his breeding trials at the Simcoe Horticultural Research Station several weeks after our visit. Unfortunately, time was not available to confirm Dr. Kerr's observations.

Conclusions

One must conclude from the observations outlined above that foliar injury to the 1975 Ontario tomato crop, while present was inconsequential at the time the survey was conducted. The weather conditions prior to the survey were probably not conducive for the production and transport of oxidants into the tomato growing areas of the Province.

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Table 1: Results of the PAN Survey of the 1975 Ontario Tomato Crop

Stop No.	Location	Variety if Known	PAN Symptoms	Remarks
1	Ridgetown College	Veemore	Trace	No symptoms on other varieties
2	4 Km W Ridgetown	1350	None	
3	4.5 Km W Ridgetown	Bravo	None	
4	16 Km WSW Chatham	C-28	None	
		1409	None	Plants were at optimum size for injury
5	6 Km E Stoney Point	1350	None	
		Roma	Trace	
6	8 Km S Belle River	Unknown	Trace	
7	4 Km W North Woodslee	Unknown	None	
8	Harrow Agricultural Research Station	Veemore	Trace	No symptoms on other varieties
		1350	None	
9	2 Km W Kingsville	1409	None	
10	6 Km E Leamington	1409	None	
		1630	None	
11	6 Km S Tilbury	1350	None	
12	5 Km NE Port Alma	1409	None	
		C.28	None	
13	4 Km SE Fletcher	Unknown	None	
14	8 Km SSE Wallaceburg	1409	Trace	
15	3 Km SSE Tupperville	Unknown	None	
16	9 Km S Ridgetown	1630	None	
		C-28	None	
		1409	Light	
17	5 Km E Palmyra	C-28	None	Leaves were covered with mud from an overnight rain
		1630	None	
		1409	None	
18	Highway 401 & 76 @ Westlorne	New Yorker	None	
		1326	None	
		1350	None	
19	6 Km W Port Bruce	Unknown	Light	
20	2 Km N Port Burwell	1350	Light	
21	3 Km E Vienna	C-28	Trace	
		1630	None	
22	9 Km WNW Clear Creek	Unknown	None	
23	3 Km E Clear Creek	Springset	Trace	
		1350	Light	
24	5 Km E Clear Creek	Unknown	Light	
25	2 Km N Port Rowan	Unknown	None	
26	3 Km W Port Dover	Big Boy	None	
		Unknown	None	
27	5 Km NE Simcoe	Unknown	None	
28	5 Km NE Simcoe	Springbrite	None	
		Veebrite	None	
		1350	None	
		C-28	None	
29	Simcoe Horticultural Research Station	Veemore	Moderate	
		Veebrite	Trace-light	
		1350	Trace	
		ST-21	Trace	
30	Highway 48 between Finch and Steeles	Unknown	None	
31	Approximately 6.4 Km N of Pickering	Unknown	None	
32	5 Km N Newcastle	Glamour	None	
33	3 Km NW Orono	Veemore	None	
34	Utica	Veemore	Trace	
35	Stouffville	Veemore	None	

.....3

Observations by Mr. R.G. Pearson, June 25 & 26, 1975.

Stop No.	Location	Variety if Known	PAN Symptoms
36	Burlington	Jet Star	None
37	Burlington	Burpies Jet Star Big Boy Roma	None
38	Vineland	Several var.	None
39	Niagara-on-the-Lake	Roma Springset	None
40	Port Maitland	unknown	trace-light
41	Port Maitland	Glammou	None
42	.8 Km N of LowBanks	Veebrite	Trace
		Roma	Trace-Light
43	.8 Km S Wainfleet	Veebriet	None
		Springset H. 1350	light
44	1.6 Km N. Binbrook	unknown	None

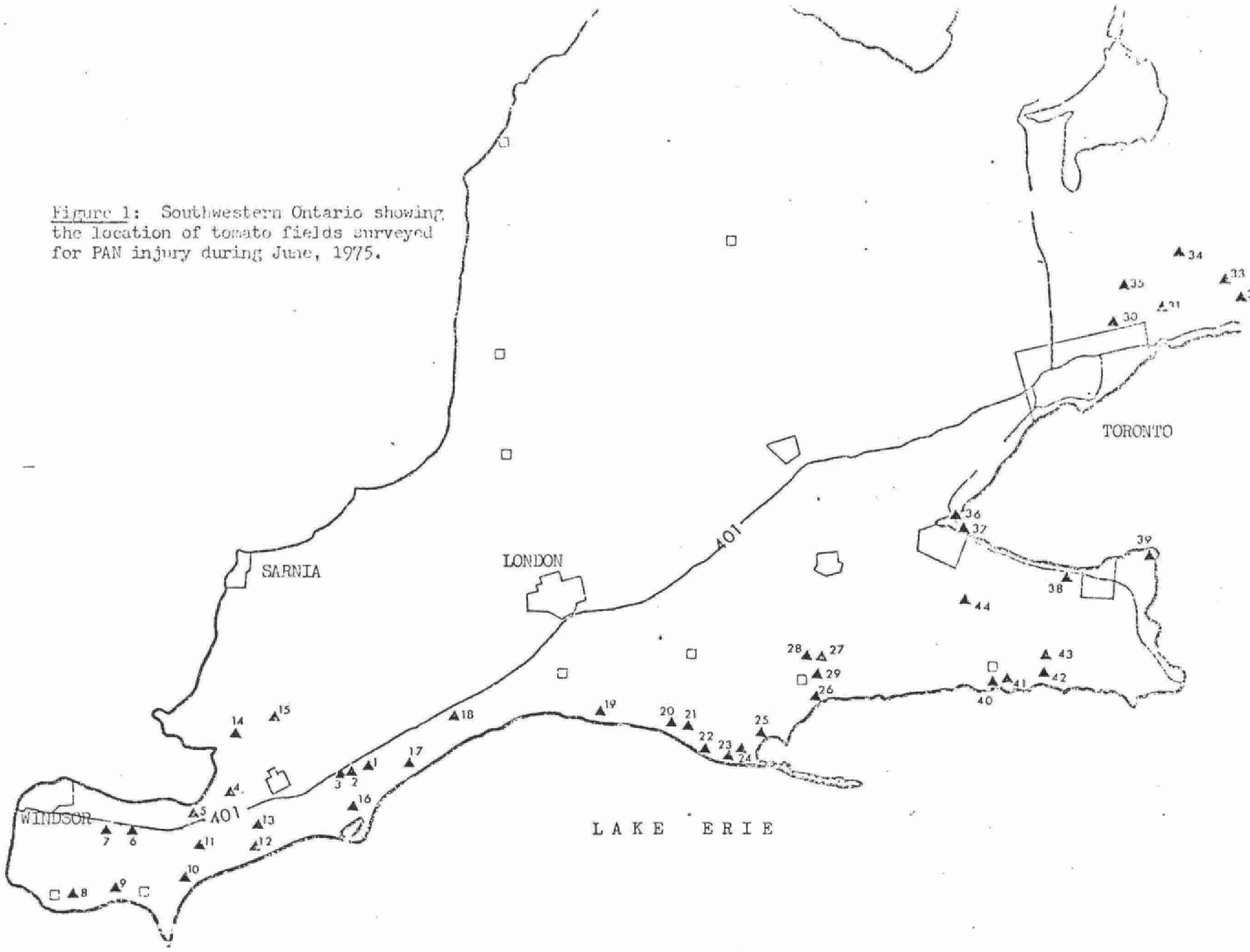

Figure 1: Southwestern Ontario showing the location of tomato fields surveyed for PAN injury during June, 1975.

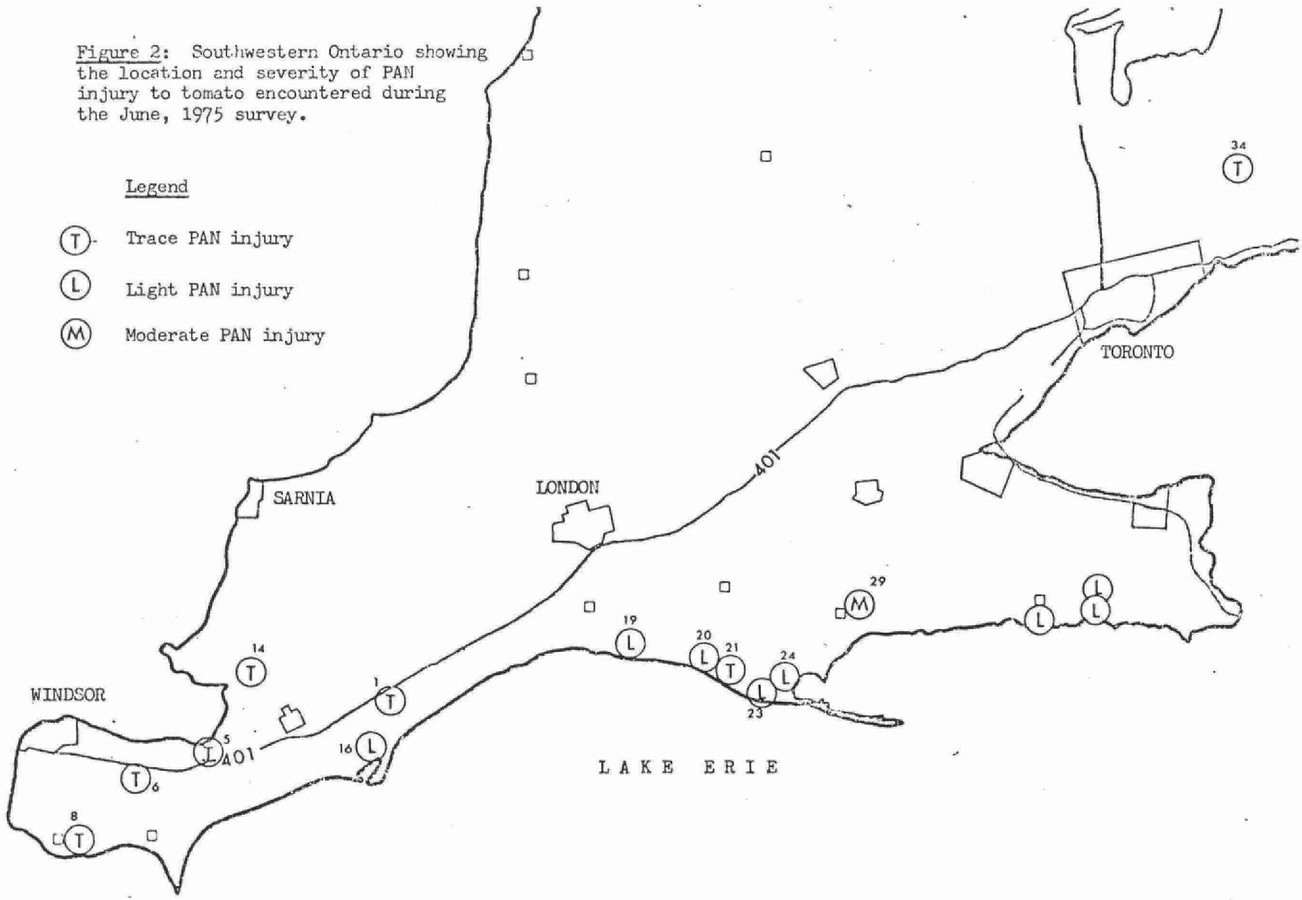

Figure 2: Southwestern Ontario showing the location and severity of PAN injury to tomato encountered during the June, 1975 survey.

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ASSESSMENT OF OZONE/PAN-TYPE INJURY TO TOMATO POTATO, TOBACCO AND MUCK CROPS IN SOUTHERN ONTARIO: 1976-1978

During the growing season from 1976 through to 1978, the degree and extent of ozone and/or PAN-type injury was assessed on a number of crops grown throughout Southern and Central Ontario. Surveys were performed for the first time in 1977 on tobacco, potato and muck crops. The following table outlines the crops examined, the pollutant, the years the surveys were performed and the geographical extent of the observations.

Crop Species	Pollutant	Year(s)	No. of Sites	No. Varieties Examined	No. Counties Covered
Tobacco	Ozone	1977	33	6	10
Potato	"	1977	18	11	9
	"	1978	15	9	9
Muck Crops	"	1977	14	8 (different crops)	4 marshes
Tomato	PAN-type	1976	50	20	14
	"	1977	44	23	10
	"	1978	20	14	6

Surveys on potato, tobacco and tomato were conducted throughout an area from Windsor and Sarnia along the N shore of Lake Erie to St. Thomas and Simcoe and to the N and NE of Toronto. Vegetable crops were inspected in primary marshes near Thedford, Pt. Pelee, Erieau and Bradford.

Generally, all surveys were conducted in a similar manner. Plantings close to the major routes were chosen at random and the grower was contacted for information concerning the varieties grown and respective planting dates. At each site, 2 to 3 representative plants were randomly selected from different locations in the field and were visually examined for foliar injury symptoms.

Assessment of injury on potato, tobacco and tomato plants was based on the following parameters:

(a) *the total number of fully developed single or compound leaves on the plant (tobacco) or a few selected vines (potato, tomato),*

(b) *the number of leaves exhibiting injury,*

and (c) *the average % injury of all affected leaves.*

These parameters were implemented in an equation $\left(\frac{B}{A} \times C\right)$ *designed to calculate the average % foliar injury to the plant. Three of these values were averaged to yield the % ozone or PAN-type injury to the foliage of the crop at each location.*

On vegetables, oxidant injury was assessed by examining a number of plants within a crop and visually categorizing the injury as trace ($<$ 1-5%), light (6-15%) or moderate (16-35%) in severity on a leaf area basis.

Suspected pollutant injury to the foliage of some of the most severely affected plants of all crops (except tobacco) was photographed and samples were collected for histological examination and preservation in the Phytotoxicology herbarium. Varietal response of all of the field crops was investigated where sufficient observations were possible.

Tomatoes

Each year, PAN-type injury surveys on tomato crops were conducted near the later part of June when most plants were in early to advanced stages of flowering. The location of all sites and relative severity of injury observed during the 3 years are shown in the attached Figures 1, 2 and 3 and Tables 1, 2 and 3, respectively.

In general, the PAN-type symptoms were similar from one year to the next and were characterized by small irregular shaped necrotic lesions giving the under leaf surfaces a glazed appearance. Lesions were grey to silver or bronze coloured (Figure 9) and often exhibited a dark brown or rustic appearance depending on age. Injury either was confined near the tip, base or margins or was interveinal and scattered over the entire under leaf surface.

In some cases, the injury had coalesced and developed bifacially. On some plants, a pattern of injury was observed similar to that described for PAN in the literature. Oldest (lower) and middle aged leaves on the plants generally showed the most injury.

During the 3 years, PAN-type injury to individual field plantings generally ranged from about 1-5%. In 1976 and 1977, light injury (6-15%) was observed on some of the more severely affected sensitive varieties. Tables 4 and 5 show that PAN-type injury was most severe in 1977 followed by 1976 and 1978.

Table 4

Severity of PAN-type Injury to Tomatoes in S. Ontario - 1976-1978*

Year	No. of Sites Examined	% of Sites with PAN-type Injury	% of Sites with > 2% PAN-type Injury	% of Sites with > 5% PAN-type Injury
1976	50	70	36	12
1977	44	100	59	25
1978	20	100	5	0

* *based on injury rating to the most severely affected variety where more than one was examined at the same location.*

Table 5 also shows that in 1976 the more severely affected areas were located to the N of Chatham (NE of Windsor and Detroit) and along the N shore of Lake Erie between St. Thomas and Port Rowan, while in 1977, the most severe injury was detected to the S of Chatham between Blenheim and Leamington close to the lake. During both years, tomato plantings farther away from the lake generally were less severely affected.

Veemore was the most sensitive tomato cultivar exhibiting PAN-type symptoms. Heinz (H-1340, H-1409, H-1630), Campbell (C-28, C-37), Veepro and Quinte also were found to be moderately susceptible.

Potatoes

During 1977 and 1978, ozone surveys on potatoes were conducted during the 3rd week of July when most plants were flowering. The location of all sites visited during the surveys is shown in Figures 4 and 5.

During the two years, the symptoms observed on potato plants were found to be similar. Injury developed on the upper and lower surfaces of affected leaves. The severity of injury observed on the upper surface of the leaves was rated independent of the lower, as shown in Tables 6 and 7.

The upper surface of the leaves showed dark necrotic stipples, and the lower surface exhibited numerous small irregular sized grey-silver (Figures 10 and 11) or bronze coloured lesions. In some cases, symptoms developed bifacially (Figure 12) and entire under leaf surfaces were glazed or exhibited a tan or rust coloured appearance. Injury to both surfaces either was confined to the tip, base or margins or was interveinally scattered over the affected leaves or leaflets. Oldest (lower) and middle positioned compound leaves on the plants generally were the most severely affected. Moreover, injury expressed on the lower surface was found on a larger number of leaves per plant and was more severe compared to the upper surface stippling.

During the two years, ozone injury ranging from < 1 to 5% was observed at most locations with the more severe injury being detected in 1977 (Tables 8 and 9).

In both years experimental plantings of sensitive Norchip potatoes grown at Simcoe showed moderate (16-35%) injury and were more severely affected than similar plantings located in other areas. Potatoes grown in the Port Stanley and Leamington areas also were more severely affected compared to other locations (Table 9).

In both years Norchip was the most sensitive potato cultivar to oxidants compared to other common varieties that were examined.

Table 8

Severity of Ozone Injury to Potatoes in S. Ontario 1977-1978*

Year	No. of Sites Examined	% of Sites with Ozone Injury	% of Sites with > 2% Ozone Injury	% of Sites with >5% Ozone Injury
1977	18	94	50	6
1978	15	100	20	0

* *based on injury rating to the most severely affected variety where more than one was examined at the same location.*

In addition to the survey on potatoes in 1978, an experiment was conducted at Simcoe to examine in greater depth undersurface injury development on potatoes (resembling PAN-type observed on tomatoes).

The experiment involved planting an early (Superior), mid-season (Norchip) and late (Kennebec) maturing variety and applying the antiozonant EDU to the foliage at regular intervals every 10, 20 or 30 days during the summer. During the times of EDU application plants were visually examined for the onset of upper and lower surface injury and, on completion of the experiment, plants were harvested for yield determinations.

The most pronounced symptoms developed on the undersurface of the leaves during the later part of July.

Injury on randomly selected plants assessed at the end of the season revealed that frequent additions (every 10 days) of EDU reduced the undersurface injury on all 3 varieties, with the greatest effect (62% reduction) being detected on Norchip.

Ambient ozone levels, which were monitored at the nearby Simcoe Horticultural Research Station, exceeded 100 ppb for four or more consecutive hours for 3 days (Table 12) during the later part of July 1978, when the injury became most pronounced.

These results support the previously published studies that have attributed the development of upper and lower surface injury to ambient ozone fumigations.

Tobacco

Ozone injury to tobacco was assessed during the first two weeks of August at which time harvesting of most varieties had just begun.

Table 10 shows the severity of injury observed on flue-cured or Burley tobacco in 1977 and all site locations are shown in Figure 6.

Injury to tobacco plants was characterized by rust to gold coloured flecks (Figure 13) on upper leaf surfaces and bleached or tan coloured bifacial lesions (Figure 14). Symptoms were mainly confined near the tip, base or margins or were scattered inerveinally over the affected leaves. The lower and middle positioned leaves on the plants were the most severely injured.

The most severely affected areas were centered around Leamington and between St. Thomas and Port Rowan. Injury in these areas ranged from trace to moderate and generally was less severe with increasing distance away from the lake.

The 2 flue-cured varieties generally appeared to be more sensitive to ozone than the Burley types.

Vegetables

In 1977, vegetable crops including carrots, celery, lettuce, onions and radish were examined several times from June through August, in order to assess ozone injury at as many different stages of maturity as possible. All of the observations were made in the four main Southern Ontario marshes which are shown in Figure 7. All crops that were examined in each area are listed in Table 11.

During August 1977, undersurface bronze coloured lesions were observed on the foliage of celery at Bradford. Onions at this site, and at all other marsh locations also displayed typical ozone symptoms which have been reported by other investigators. Injury to radish, which was observed at Pt. Pelee consisted of chlorotic stipples, bronzing and anthocyanosis on the upperside of the oldest leaves.

In all cases, injury to the various species was trace in severity and appeared more pronounced during the later part of the summer. This was attributed to more frequent ozone episodes during this time, and to the fact that plants generally were older and more sensitive to ozone compared to less physiologically active stages of growth earlier in the season.

Ozone Data

Ozone levels monitored at various locations during the past 3 summers were, at times, conducive to injure most sensitive crops grown in S. Ontario. Ozone levels monitored at four locations in the Province (Figure 7) from 1976 to 1978 are summarized in Table 13.

With the exception of Stouffville, mean growing season values were higher in 1977 than in 1976 or 1978 and, on average, were highest at stations located nearest the lake (Merlin and Simcoe). In addition, ozone levels exceeding the MOE criterion of 80 ppb generally were recorded more frequently at these two stations compared to other locations.

On the basis of the Simcoe data (Table 12) which was partitioned to correspond with the various stages of potato development, it is apparent that in 1976 and 1978, ozone levels were highest (100 ppb for 4 or more consecutive hours) during the first half of June when most potatoes were still young, physiologically immature, and relatively resistant. In 1977, higher ozone levels were recorded during the later half of June when plants were older, physiologically more mature and more sensitive. The fact that most crops were planted earlier in 1977 than 1976 and 1978 would have further accentuated this maturity effect.

Histological Findings

In general, ozone and/or PAN-type injury suspected on potato, tomato, celery, onion and radish crops during the 3 years was confirmed by histological techniques.

During 1977 and 1978, histological examination of the affected leaf tissues of potato revealed that the injury on the undersurface of the leaves (resembling PAN) was more characteristic of ozone injury documented on bean and tobacco.

Histological photomicrographs of the undersurface PAN-type injury on potato and tomato are shown in Figure 8. Photograph 1 reveals a more vertical and inward development of injury on the lower leaf surface of potato compared to cellular collapse and horizontal development along the lower epidermis (Photograph 2) of tomato leaves.

Conclusion

During 1976 to 1978, atmospheric ozone levels were conducive to injure the foliage of most sensitive crop species grown in southern Ontario. Generally, hostopathological findings and ambient ozone levels which were monitored during the 3 summers at different locations across the province, supported the visual observations.

During the surveys, the degree of ozone injury on potato and, tobacco and PAN-type injury on tomato crops ranged from trace to moderate in severity and generally was less at increasing distance N from the shores of Lake Erie. During the 3 years, the most severely affected areas were centered around Simcoe, to the N of Chatham and along the N shore of Lake Erie between Port Rowan and St. Thomas.

Varietal studies showed that Norchip was the most ozone sensitive potato cultivar while Veemore tomatoes exhibited the most severe PAN-type symptoms. Flue-cured varieties of tobacco generally were more sensitive to ozone than the Burley species.

Vegetable crops in the four main marsh production areas of Southern Ontario, that were examined, exhibited trace ozone injury in 1977 which generally became more apparent as the season progressed.

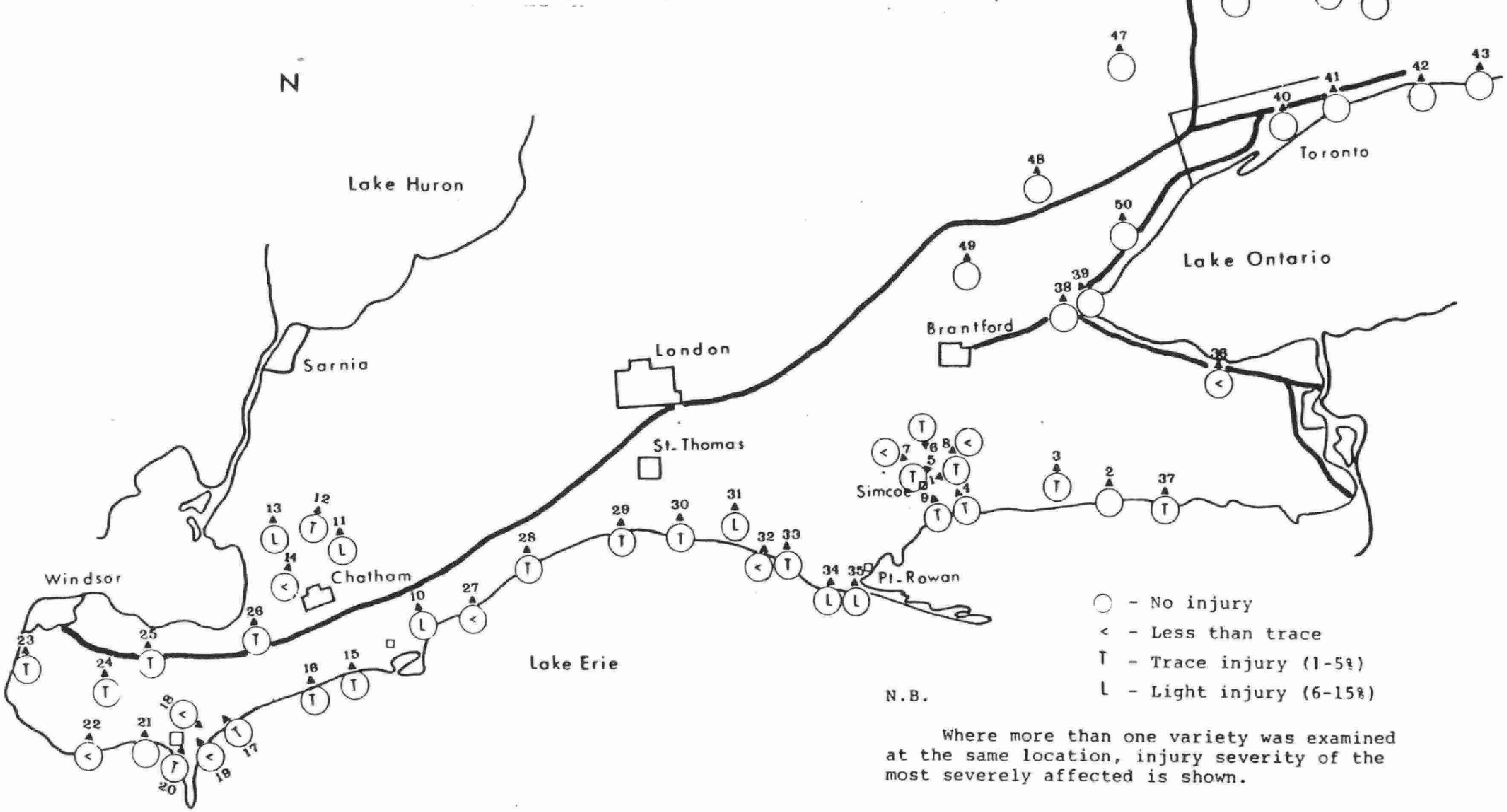
RGP/hm

Attach.

PH/35/2

R.N. EMERSON
Plant Scientist
Vegetation Assessment Unit
Phytotoxicology Section.

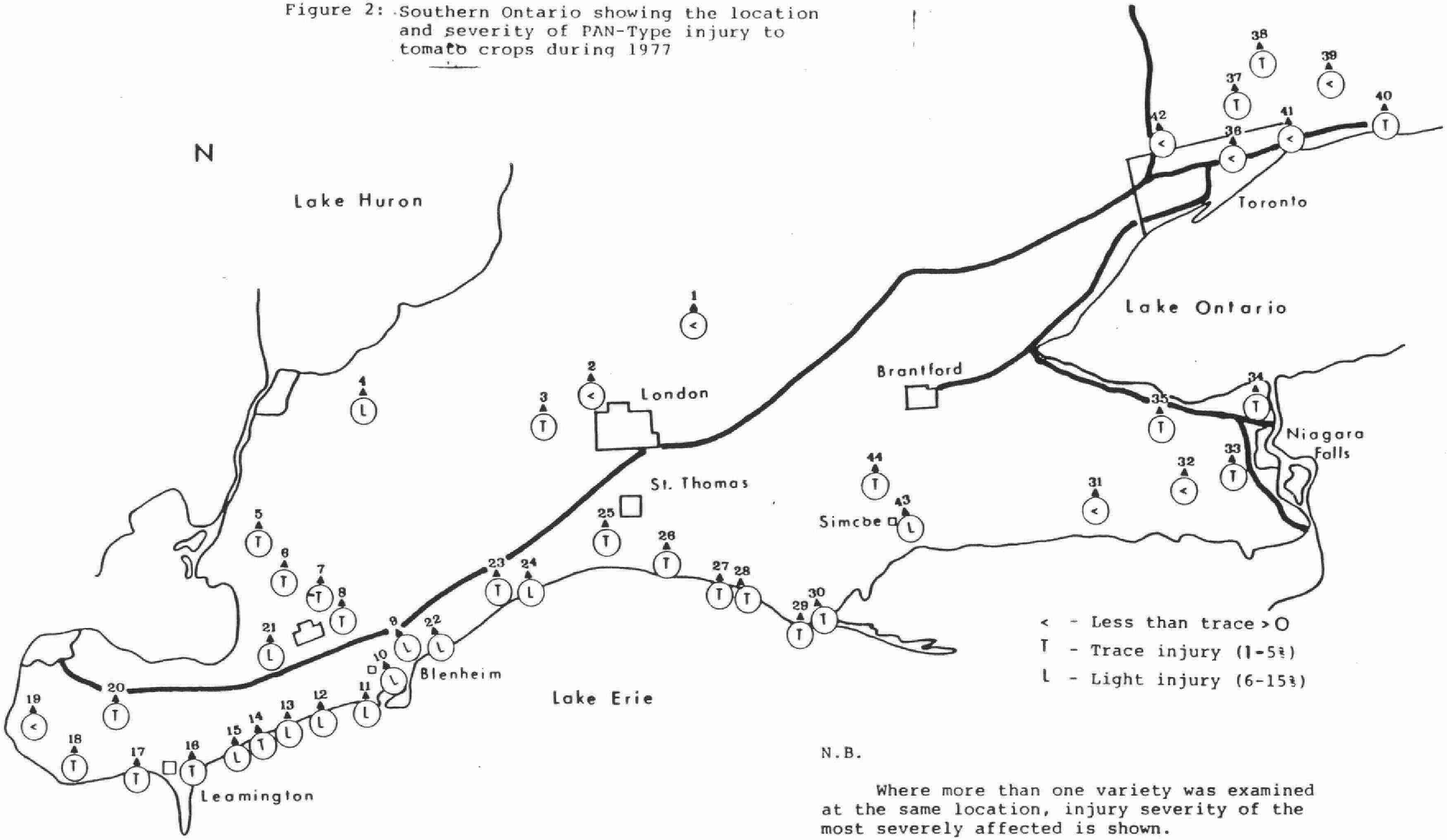
Figure 1 : Southern Ontario showing the location and severity of PAN-Type injury to tomato crops during 1976.



N.B.

Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 2: Southern Ontario showing the location and severity of PAN-Type injury to tomato crops during 1977

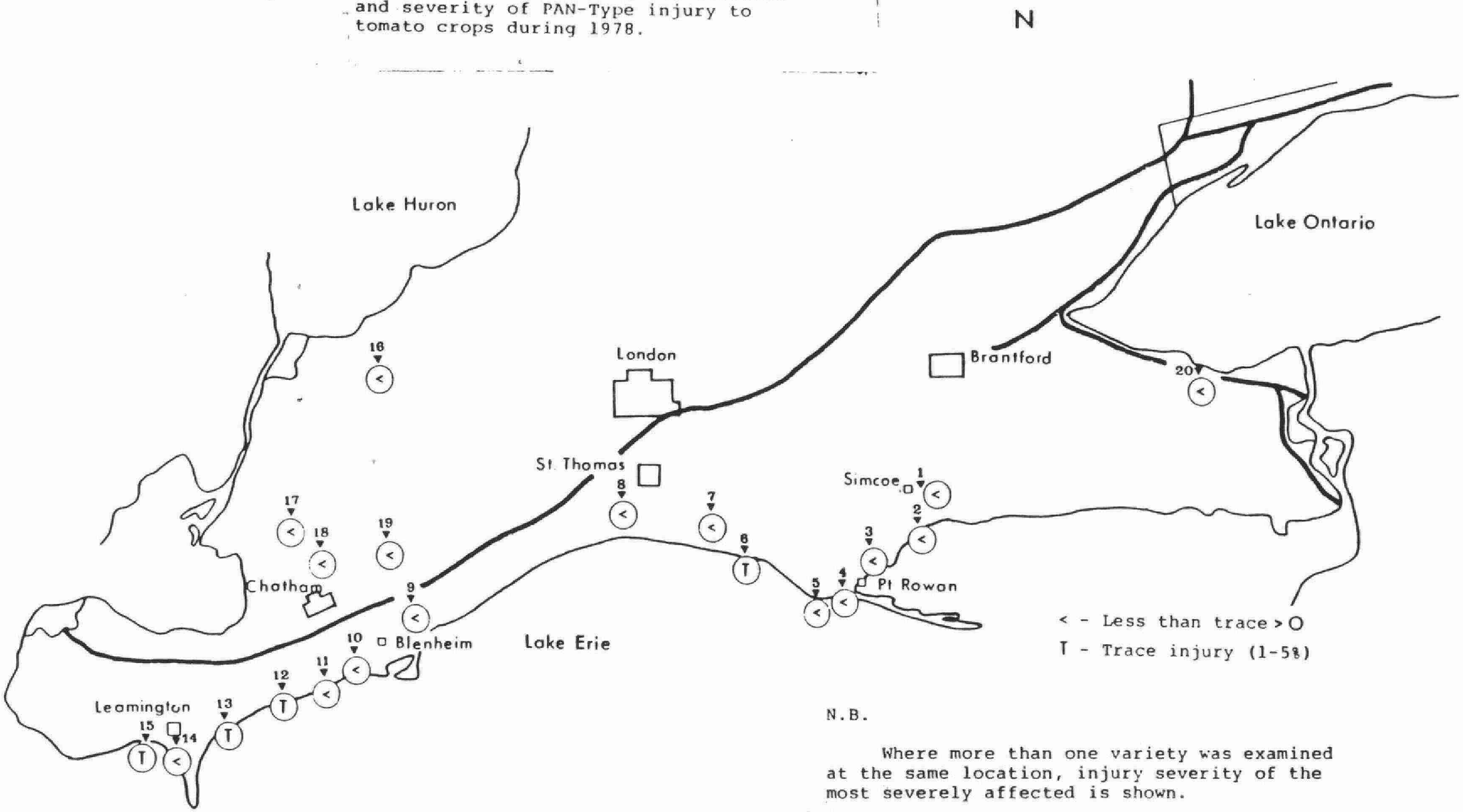


< - Less than trace > 0
T - Trace injury (1-5%)
L - Light injury (6-15%)

N.B.

Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 3 : Southern Ontario showing the location and severity of PAN-Type injury to tomato crops during 1978.

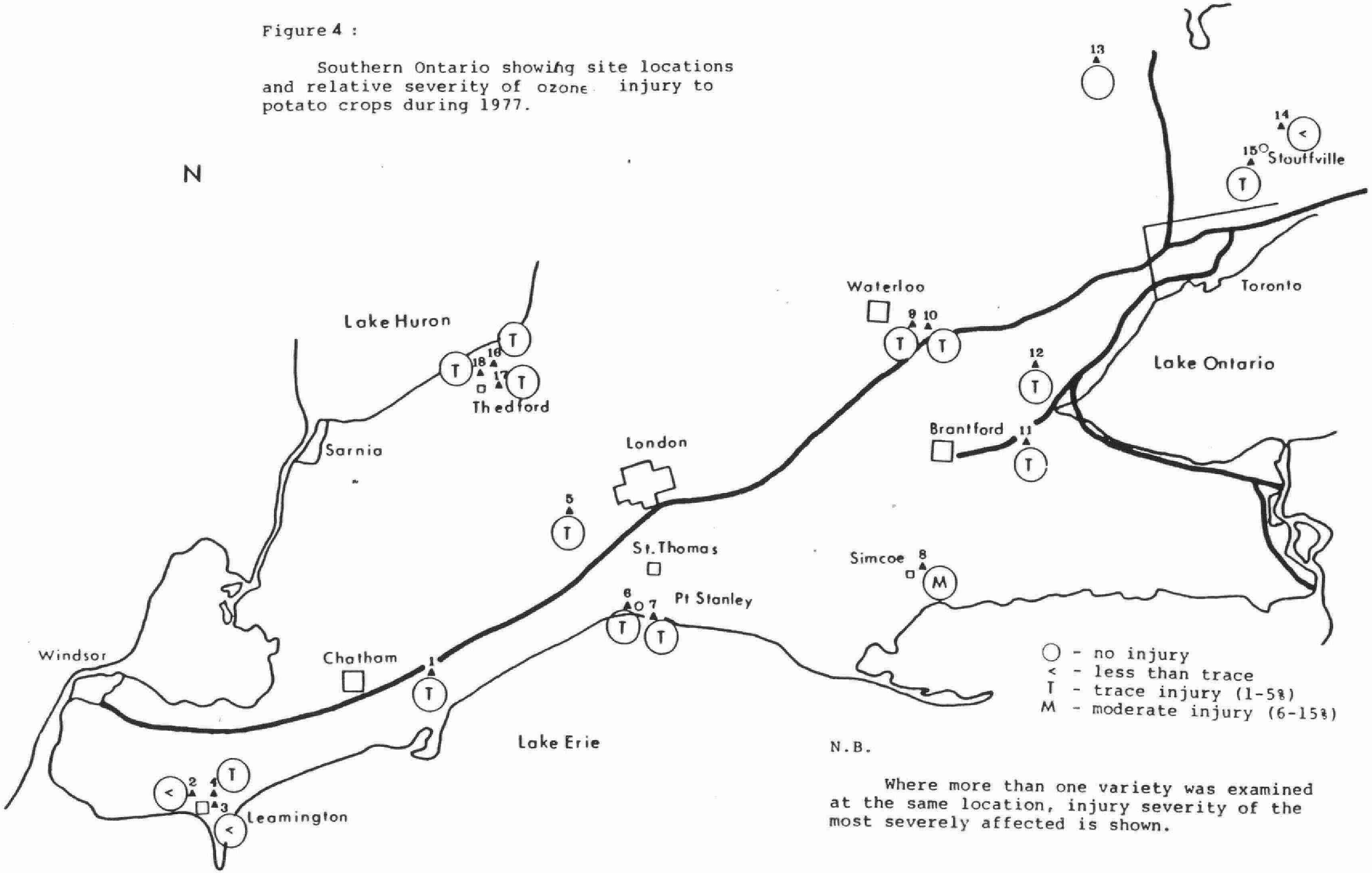


N.B.

Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 4 :

Southern Ontario showing site locations and relative severity of ozone injury to potato crops during 1977.

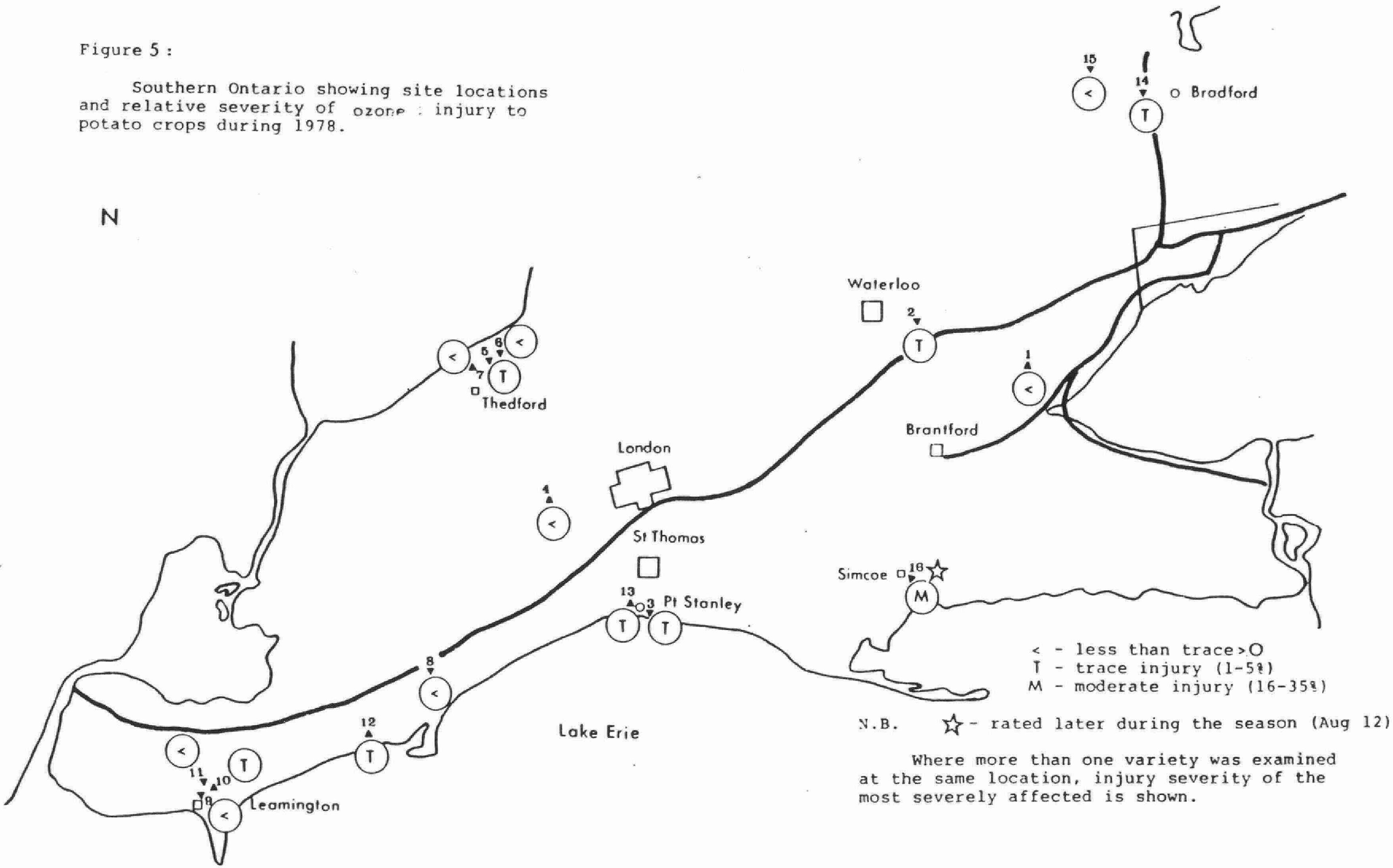


N.B.

Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 5 :

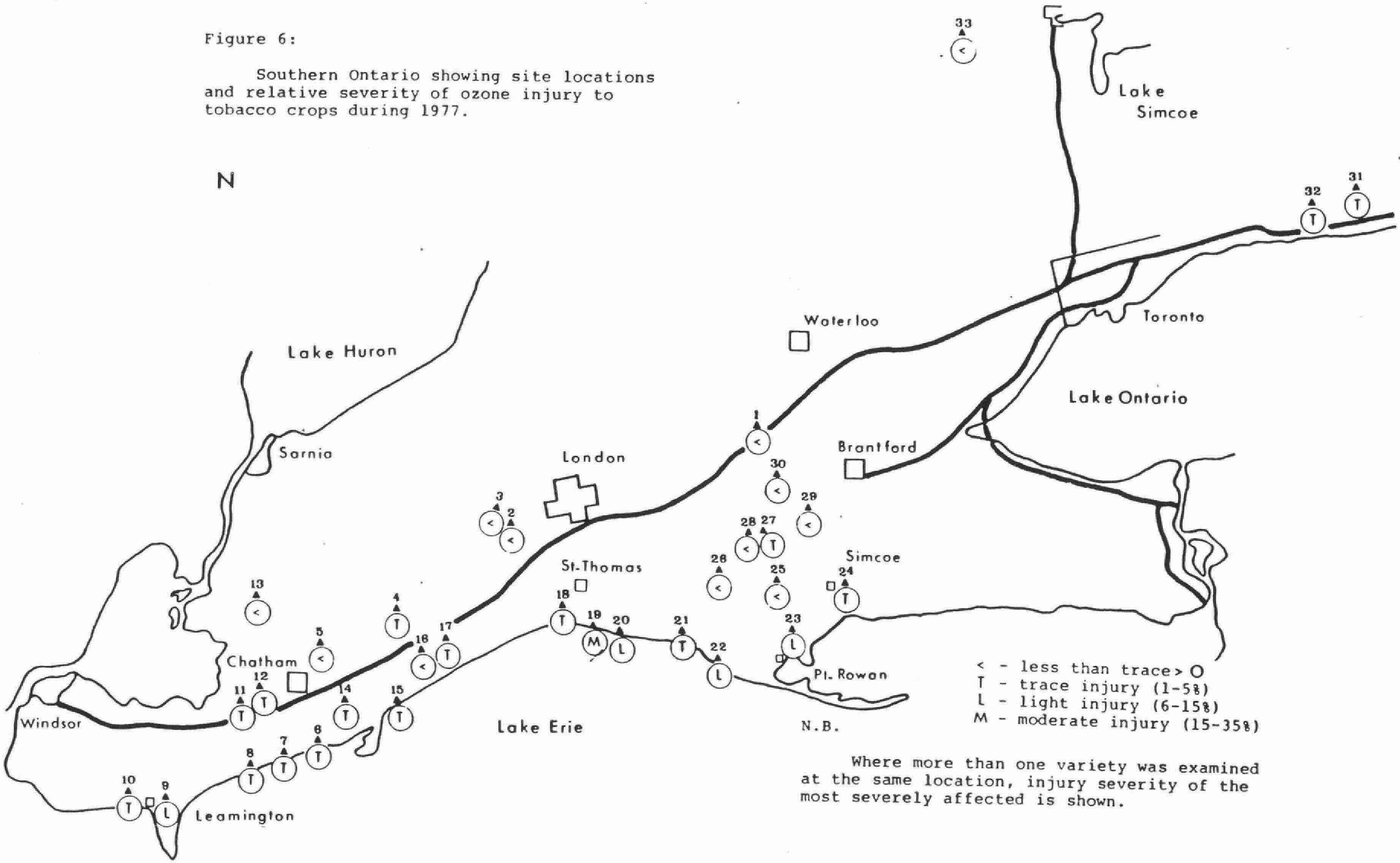
Southern Ontario showing site locations and relative severity of ozone : injury to potato crops during 1978.



Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 6:

Southern Ontario showing site locations and relative severity of ozone injury to tobacco crops during 1977.



< - less than trace > O
T - trace injury (1-5%)
L - light injury (6-15%)
M - moderate injury (15-35%)

Where more than one variety was examined at the same location, injury severity of the most severely affected is shown.

Figure 7 - Southern Ontario showing the muck crop areas examined during 1977; in addition, the location of 4 MOE ozone monitoring stations.

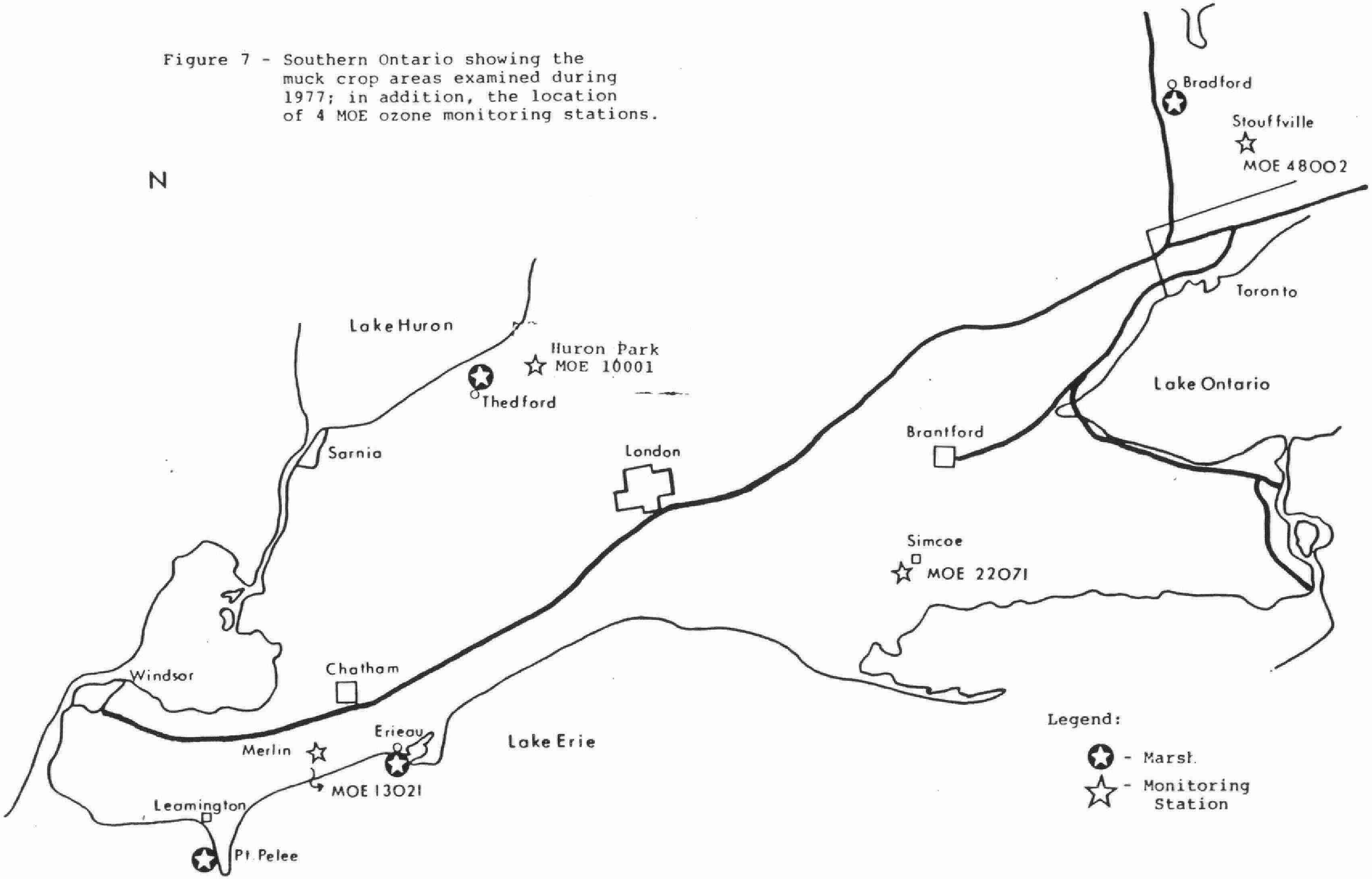


Figure 8

Histological Photomicrographs Showing Structural Differences Between the Undersurface Injury to Potato and Tomato

Photo 1: (Potato) Showing injury development to paraveinal and upper and lower spongy parenchyma cells and air pocket formation between the outer spongy tissues and lower epidermis

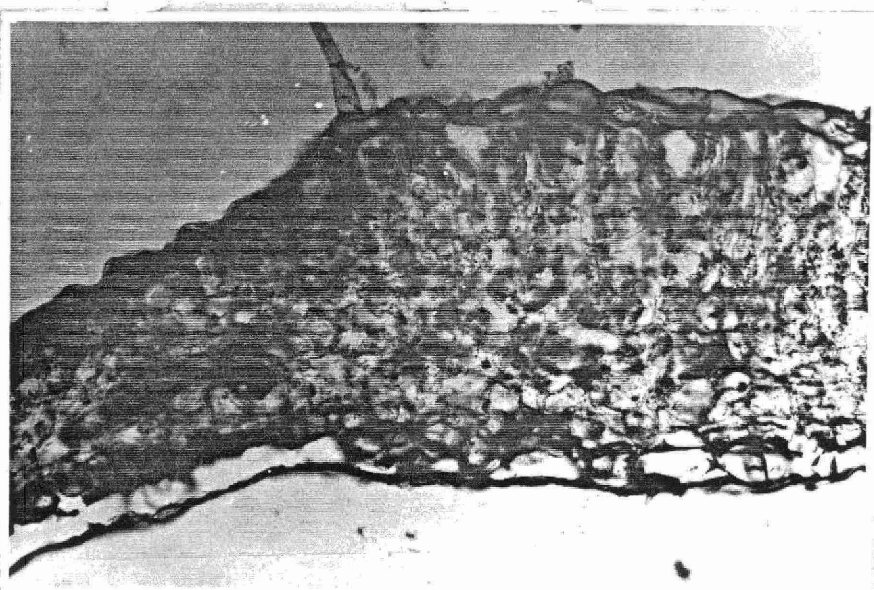


Photo 2: (Tomato) Cross section showing airpocket formation between collapsed outer spongy parenchyma cells and lower epidermis

Figure 9

Undersurface of Tomato Leaflets Showing
Tan or Bronze Coloured Lesions.

Figure 10 - Grey to Rust Coloured Irregular Shaped Lesions on the Undersurface of a Potato Leaflet

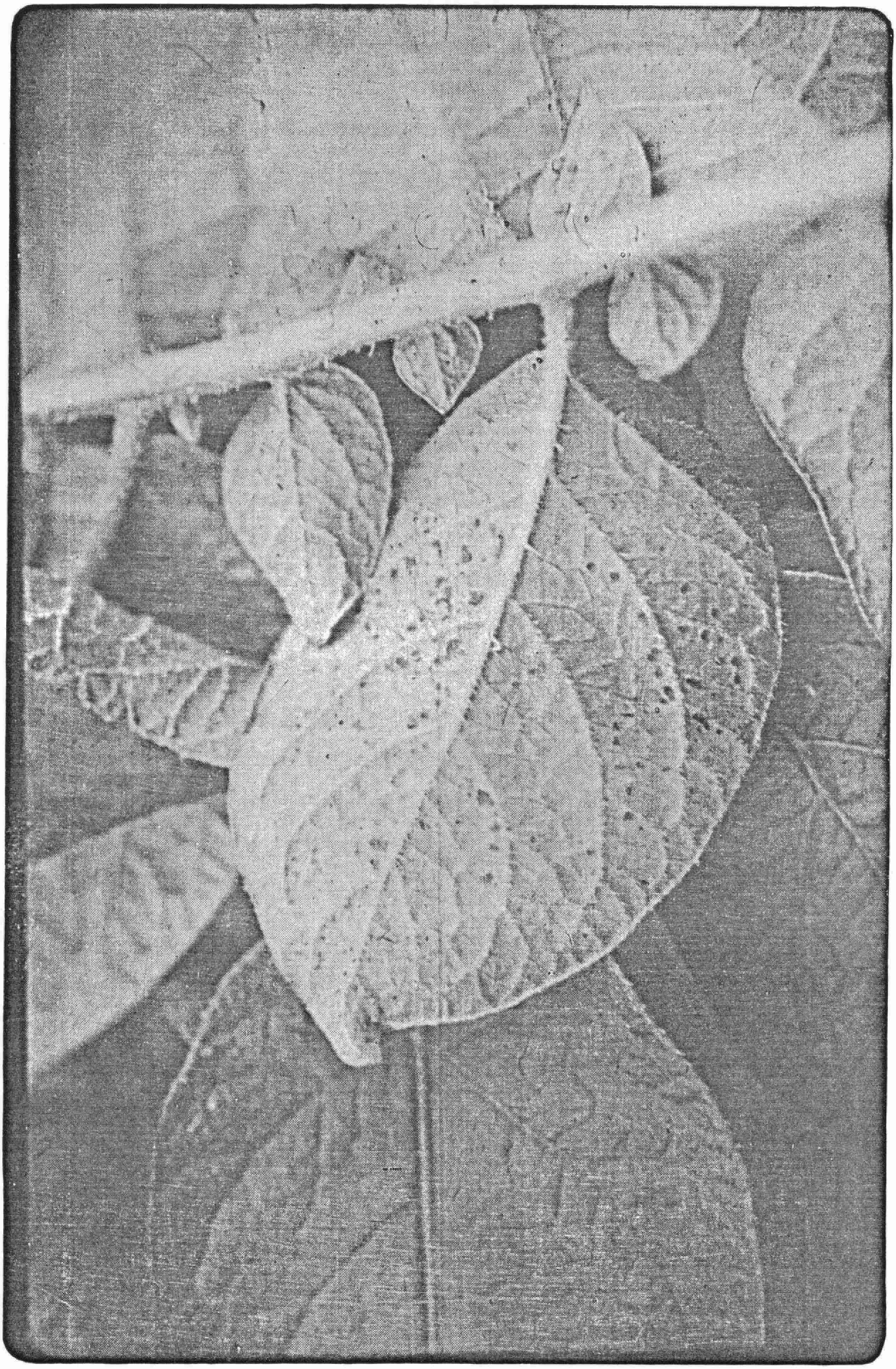


Figure 11 - Potato Leaflet (undersurface) Showing Grey to Silver Coloured Coalescing Sunken Lesions

Figure 12 - Potato Leaflets (upper surface) Manifesting Bifacial Injury Development

Figure 13 - Rust or Gold Coloured Flecks on the Uppersurface of a Tobacco Leaves

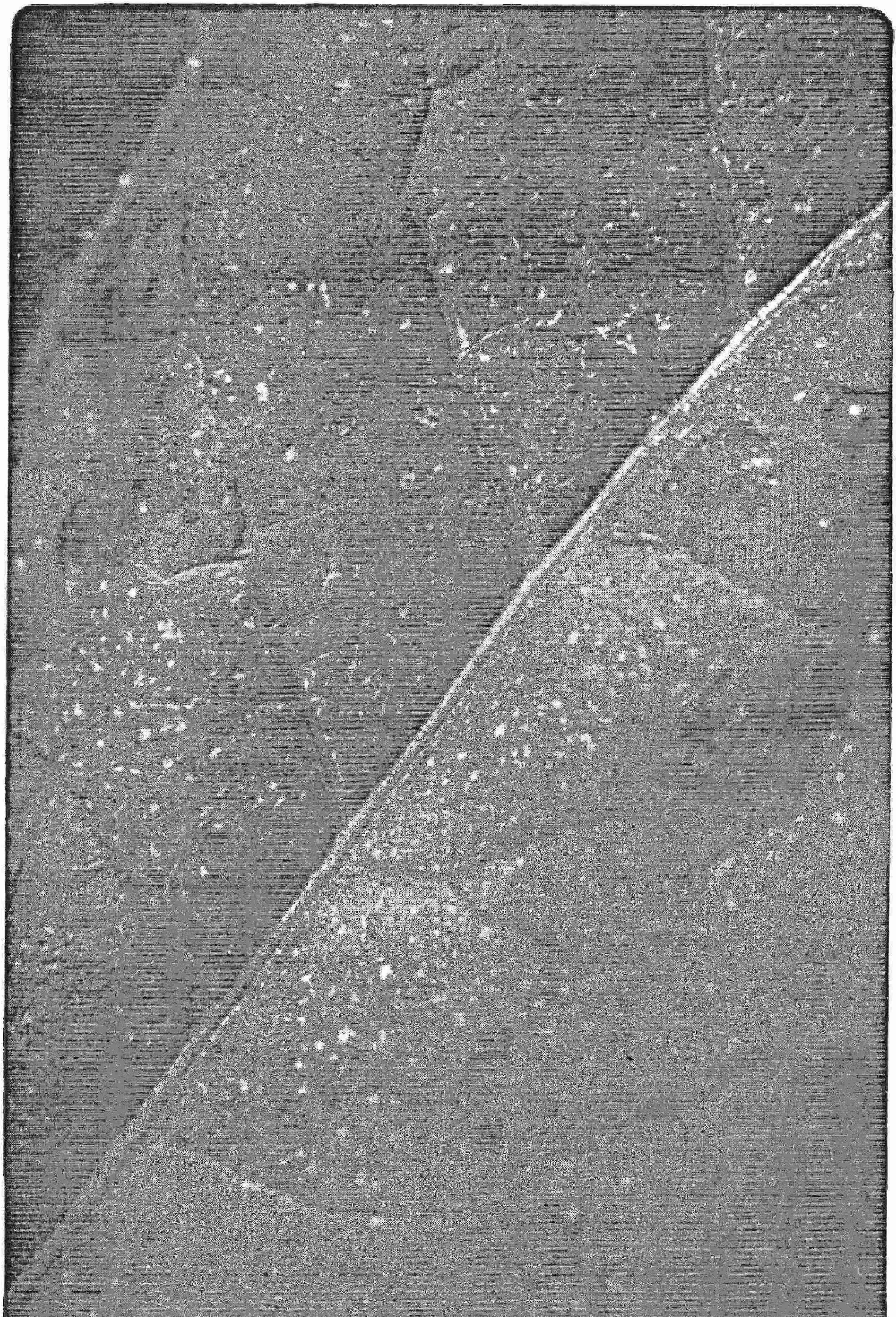


Figure 14 - Tobacco Foliage Showing Bleached or Tan Coloured Bifacial Lesion

TABLE 1

Severity of PAN-type Injury on Tomato Crops in S. Ontario
- June, 1976 -

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury**							
			Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
1	5 km ENE Simcoe	April 20							0.9	$4.6^{(1)}$ $0.3^{(d)}$ $0.5^{(c)}$ $0.6^{(a)}$
2	4 km W NW S. Cayuga	May 28								$0^{(n)}$
3	1 km S Nelles Corners	May 27		1.5						$2.2^{(b)}$
4	3 km SW Jarvis	May 18								$1.5^{(n)}$
5	4 km NE Simcoe	May 28								$0.7^{(j)}$ $1^{(k)}$
6	6 km N Simcoe	May 14 $28^{(3)}$			2.4			0.9		
7	6 km NW Simcoe	May 21								$0.4^{(e)}$
8	10 km NE Simcoe	May 19					0.9			$0.7^{(e)}$
9	5 km ESE Simcoe	May 18			0.5		1.5			

(Table 1 continued)

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury** Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
10	1 km NE Ridgetown	May 21					2.5		3.2	$1.3^{(m)}$ $0.8^{(d)}$ $5.2^{(1)}$
11	2 km ESE Dresden	May 12			7.4					
12	4 km NW Dresden	May					1.3			
13	2 km ENE Wallaceburg	May				6.8				$1.7^{(c)}$
14	4 km NE Dover Centre	May 5^{a} 13^{n}, 14^{3}			0.4					$0.3^{(n)}$ $0.1^{(a)}$
15	4 km WSW Cedar Springs	May 21				1.5				
16	12 km WSW Cedar Springs	May 14				2.8				
17	2 km E Wheatley	May 19			1.3					$3.2^{(i)}$
18	2 km W Wheatley	June 3								$0.3^{(n)}$

(Table 1 continued)

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury**							
			Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
19	6 km SW Wheatley	May 15								0.1[j]
20	2 km SE Leamington	May 15					2.9			1.0[h]
21	3 km E Kingsville	May 13				0				
22	2 km SE Harrow	May 21					0.2			0.6[h]
23	4 km S La Salle	-						2.8		
24	2 km ENE Essex	May 24			1.6					
25	4 km kNE Woodslee	May 18			2.0					
26	3 km W Jeannette Creek	May 18								1.1[n]
27	3 km E Palmyra	May 20				0.1				
28	5 km E Rodney	May 15								2.9[n]

(Table 1 continued)

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury**							
			Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
29	2 km WSW Fingal	-								$1.3^{(n)}$
30	2 km W Sparta	May 12								$3.4^{(f)}$
31	2 km S Aylmer	June 12		5.1						
32	2 km W Port Burwell	May 14			0.6					
33	3 km ENE Port Burwell	June 6			3.6					
34	2 km E Clear Creek	May 8			8.5					
35	4 km SSW Pt. Rowan	May 14			5.1					
36	5 km NNW Vineland	May 30						0.1	0.2	
37	1 km N Pt. Maitland	-								$3.6^{(n)}$
38	4 km WSW Burlington	-								$0^{(g)}$

(Table 1 continued)

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury** Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
39	4 km NNE Burlington	-								0(n)
40	Scarborough (NE)	-								0(j)
41	2 km NW Pickering	June 7	0							
42	1 km S Courtice	June 1		0						
43	2 km NE Newcastle	May 24		0						
44	1 km W. Pt. Perry	June 1	0							
45	2 km N. Pt. Perry	June 1		0						
46	2 km E. Holland Landing	-	0							
47	3 km S. Palgrave	May 24	0							
48	4 km WSW Acton	May 26								0(b)

(Table 1 continued)

Site	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % of Foliar Injury**							
			Beef-steak 1	Bonny Best 2	Heinz 1350 3	Heinz 1630 4	Ottawa's 5	Spring-set 6	Veebrite 7	Other
49	1 km NW Cambridge	May 26								0[(i)]
50	8 km NW Oakville	June 1	0							

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

*** (a) Campbell 28; (b) Glamour; (c) Heinz 1409; (d) Heinz 1706; (e) Heinz 7193; (f) Hybrid Big Boy; (g) Jetstar; (h) Layfayette; (i) New Yorker; (j) Roma; (k) Starfire; (l) Veemore; (m) Veeroma; (n) Unknown.

TABLE 2

Severity of PAN-type Injury on Tomato Crops in S. Ontario
- June, 1977 -

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**								
			Campbell 28 1	Campbell 37 2	1350 3	1409 4	New York 5	Ottawa 6	Springset 7	Veebrite 8	Other***
1	8 km SW Stratford	May 10									$0.8^{(a)}$
2	3 km E Ilderton	May 10									$0.2^{(o)}$
3	3 km NE Poplar Hill	June 2									$2.8^{(a)}$
4	4 km N Wyoming	May 16-17			6.0						
5	1 km W Becher	May 16	2.4	1.4							
6	1 km S Tupperville	May 16			2.9						
7	8 km SSE Dresden	May 8^5, 14^3			4.6		2.6				
8	5 km SW Kent Bridge	May 12	3.3	3.3							

(Table 2 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**								
			Campbell 28 1	Campbell 37 2	1350 3	1409 4	New York 5	Ottawa 6	Springset 7	Veebrite 8	Other***
9	2 km SW Ridgetown	May 16	4.4	2.6	4.2						5[l], 5.6[m], 3.4[k]
10	6 km SW Morpeth	May 10[h], 15[4], 20[6]				5.8		3.8			3.1[(h)]
11	3 km N Erieau	May 14[h], 20[1]	3.8								6.4[(h)]
12	10 km WSW Cedar Springs	May 6		6.0							
13	4 km SW Merlin	May 10				8.0					
14	4 km SW Pt. Alma	May 9					3.6				
15	6 km NE Wheatley	May 12						7.1			
16	6 km E Leamington	May 10			1.6						
17	1 km S Ruthven	May 12									1.6[(o)]
18	3 km E Harrow	May 15					2.7		3.4		

(Table 2 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**								
			Campbell 28 1	Campbell 37 2	1350 3	1409 4	New York 5	Ottawa 6	Springset 7	Veebrite 8	Other***
19	3 km N Amherstburg	May 24									$0.9^{(o)}$
20	6 km NE Essex	May 10									4.4^{j}, 3.6^{h}, 0.4^{g}
21	6 km W Chatham	May 12				5.6					
22	1 km NE Palmyra	May 15^{4}, 18^{1}	1.3			5.7					
23	3 km SE West Lorne	May 24	3.3								
24	1 km S Wallacetown	May 30			6.3					3.7	
25	3 km SW St. Thomas	May 16		4.4				4.0		3.5	$3.3^{(c)}$
26	4 km NE Sparta	May 25									$1.0^{(i)}$
27	2 km Pt. Burwell	May 25			4.4						
28	1 km N Pt. Burwell	May 18	4.2								

(Table 2 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**								
			Campbell 28 1	Campbell 37 2	1350 3	1409 4	New York 5	Ottawa 6	Springset 7	Veebrite 8	Other***
29	1 km Ne Clear Creek	May 13[7], 22[3]			2.3				1.5		
30	5 km NE Clear Creek	May 21			3.1						
31	11 km N Dunnville	May 24									0.9[b]
32	4 km SW Fonthill	May 24									0.6[b]
33	2 km SW Niagara Falls	May 24								1.5	
34	1 km N Virgil	May 24		0.9					1.0		1.2[e]
35	2 km WNW Vineland	May 26-June 6							0.5	2.3	
36	NE Toronto	-									0.3[o]
37	3 km SE Ringwood	May 28			1.0				0.6		

(Table 2 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**								
			Campbell 28 1	Campbell 37 2	1350 3	1409 4	New York 5	Ottawa 6	Springset 7	Veebrite 8	Other***
38	1 km N Goodwood	May 28									1.3[(d)]
39	1 km W Raglan	May 20[d], 24[a,7]							0.8		0.8[d], 0.5[a]
40	1 km E Courtice	May 24[k], June 4[a]									0.1[(a)], 1.1[(k)]
41	2 km NW Pickering	May 18[a], 25[f]									0.5[(f)], 0.2[(a)]
42	1 km S Maple	-									0.4[(o)]
43	3 km NE Simcoe	May 28	2.7	0.7			0.8	1.1	1.4	5.7	3.1[(j)], 1.1[n], 2.5[(m)], 1.7[(k)], 0.6[(c)], 1.5[(g)]
44	1 km N Vanessa	May 20						1.1			

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

***

a	Beefsteak	f	Glamour	k	Roma
b	Bonnybest	g	Heinz 1706	l	Veemore
c	Campbell 38	h	Heinz 1630	m	Veepro
d	Early Boy	i	Lafayette	n	Veeroma
e	Early Lady	j	Quinte	o	Unknown

TABLE 3

Severity of PAN-type Injury on Tomato Crops in S. Ontario
- June, 1978 -

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Planting Date(s)	*Average % Foliar Injury**						
			Campbell 28	Campbell 38	Heinz 1350	Heinz 1630	Springset	Veebrite	Other***
1	5 km ENE Simcoe	-	0.1						0.1[(b)], 0.2[(h)]
2	3 km NW Pt. Ryerse	May 20					0.1		0.1[(e)]
3	8 km NW Turkey Pt.	June 1						0.8	
4	4 km WSW Pt. Rowan	May 19, 20					0.5		
5	1 km ESE Clear Creek	May 25			0.9		0.6		
6	2 km WNW Iroquois	May 15			1.2		1.0		
7	3 km SE Alymer	May 28	0.5						
8	3 km W St. Thomas	May 15	0.9	0.2					0.3[(a)]

(Table 3 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Planting Date(s)	*Average % Foliar Injury**						
			Campbell 28	Campbell 38	Heinz 1350	Heinz 1630	Springset	Veebrite	Other***
9	1 km NE Ridgetown	May 19	0.3	0.3			0.3	0.3	$0.3^{(b)}$
10	4 km WSW Blenheim	-							$0.4^{(i)}$
11	9 km WSW Cedar Springs	May 10							
12	2 km N Pt. Alma	May 20	0.9						$5^{(c)}$
13	2 km E Wheatley	May 20	0.3						$2^{(c)}$
14	3 km ENE Leamington	May 22							$0.5^{(d)}$, $0.3^{(b)}$
15	3 km S Ruthven	May 24							$1^{(f)}$
16	8 km NE Dresden	May 15			0.8	0.5			
17	4 km NNE Tupperville	May 20			1.0				
18	6 km SSE Dresden	May 15			0.9				

(Table 3 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Planting Date(s)	*Average % Foliar Injury**						
			Campbell 28	Campbell 38	Heinz 1350	Heinz 1630	Springset	Veebrite	Other***
19	4 km N Thamesville	May 20			0.6				0.5[g]
20	5 km NNW Vineland	May 20						0.3	

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

***

a	Campbell 37	e	Jetstar
b	Heinz 1706	f	New Yorker
c	Heinz 1409	g	Ottawa
d	Heinz 6919	h	Veepro
		i	Unknown

TABLE 5

Severity of Pan-type Injury on Heinz 1350 at Similar Locations
- 1976-1978 -

		1976			1977			1978		
County		Site No. ( )	Average* % Injury**	Severity Category	Site No. ( )	Average* % Injury**	Severity Category	Site No. ( )	Average* % Injury**	Severity Category
Essex		(24)	1.6	T	(20	4.4	T			
Kent	(N. shore of Lake Erie)	(15)	1.5	T	(11)	6.4	L			
		(16)	2.8	T	(13)	8	L			
		(27)	.1	T	(22)	5.7	L			
	(N. of Chatham)	(11)	7.4	L	(7)	4.6	T	(18)	.5	T
		(13)	6.8	L	(6)	2.9	T	(17)	1	T
		(14)	.4	T	(21)	5.6	L			
Elgin		(32)	.6	T	(27)	4.4	T	(6)	1.2	T
Haldimand-Norfolk	(Pt. Rowan Area)	(34)	8.5	L	(29)	2.3	T	(5)	.9	T
		(35)	5.1	L	(30)	3	T			

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as determined in the text.

TABLE 6

Severity of Ozone Injury to Upper and Lower Surfaces of Potato Foliage - July, 1977

Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																					
		Belleisle 1		Cheiftain 2		Irish Cobbler 3		Kennebec 4		Keswick 5		Katahdin 6		Netted Gem 7		Norchip 8		Onaway 9		Sebago 10		Superior 11	
		U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
1 km ENE Ridgetown	May 10	0.2	0.1	0.1	0.3			0	0.4	1.0	1.2			0.6	0.4	0.3	0.3	0	0.5	0	0.3		
6 km N Leamington	Apr 10							0.4	0.3														
4 km N Leamington	Apr 6																					0.2	0.2
8 km NE Leamington	Apr 10[4], 24[8]							0.1	2.2							2.0	2.1						
2 km S Mt. Brydges	May 16							0	1.3					0	0.8								
2 km W Pt. Stanley	May 16	0.9	1.9													2.7	2.1			0.1	1.5	0.5	1.3
6 km E Pt. Stanley	Apr 15[11], May 1[4]							0.7	2.8												0.4	1.2	
3 km ENE Simcoe	May 6							0.1	3.9					1.6	4.8	1.8	26.0				0	0.7	
4 km W Hespeler	May 3					0.1	0.9																

(Table 6 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																					
			Belleisle 1		Cheiftain 2		Irish Cobbler 3		Kennebec 4		Keswick 5		Katahdin 6		Netted Gem 7		Norchip 8		Onaway 9		Sebago 10		Superior 11	
			U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
10	3 km W Hespeler	May 3							0	1.7														
11	4 km E Ancaster	May 6							0	0.8							0.9	1.7						
12	3 km ESE Carlisle	May 15[8], 18[6]											0	1.6			1.0	1.2						
13	4 km E Alliston	May 4															0	0						
14	1 km E Goodwood	May 15							0	0.8														
15	4 km S Stouffville	May 15			0.1	3.8	0.1	2.6																
16	7 km N Thedford	May 14											0.7	2.5										
17	3 km NE Thedford	Apr 24																			0.1	1.3		

(Table 6 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																					
			Belleisle 1		Cheiftain 2		Irish Cobbler 3		Kennebec 4		Keswick 5		Katahdin 6		Netted Gem 7		Norchip 8		Onaway 9		Sebago 10		Superior 11	
			U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
18	6 km NW Thedford	June 8							0	0.5													0	.8

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

U - upper leaf surface.

L - lower leaf surface.

TABLE 7

Severity of Ozone Injury on the Upper and Lower Surfaces of Potato Foliage - July, 1978 -

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																	
			Cheiftain		Kennebec		Katahdin		Netted Gem		Norchip		Norland		Ontario		Sebago		Superior	
			U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
1	3 km ESE Carlisle	May 20									0	0.1							0	0.8
2	4 km NNW Hespeler	May 12					0	1.0											0	0.5
3	5 km E Pt. Stanley	Apr 20-May 1			0	1.5													0	1.5
4	3 km WNW Mt. Brydges	Apr 12			0	0.8			0	0.1										
5	9 km NNE Thedford	May 12					0.3	2.0												
6	7 km SSW Grand Bend	-					0	0.5												
7	6 km NW Thedford	June 6	0	0	0	0											0	0		
8	1 km NE Ridgetown	-	0	0.3	0	0.1	0	0.2	0	0	0	0					0	0.4	0	0

(Table 7 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																	
			Cheiftain		Kennebec		Katahdin		Netted Gem		Norchip		Norland		Ontario		Sebago		Superior	
			U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
9	4 km NE Leamington	Apr 10																	0	0.5
10	8 km NE Leamington	Apr 10			0	1.1														
11	6 km NE Leamington	May 10									0	0.2								
12	2 km W Cedar Springs	Apr 10			0	0.5					0	1.8							0	0.2
13	1 km NW Pt. Stanley	May 12-27									0	3.6							0	0.5
14	8 km W Bradford	Apr 20	2.1	1.7																
15	3 km E Alliston	May 4									0	0	0	0	0	0.9				

(Table 7 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Planting Date(s)	*Average % Foliar Injury**																	
			Cheiftain		Kennebec		Katahdin		Netted Gem		Norchip		Norland		Ontario		Sebago		Superior	
			U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
***16	3 km ENE	May 24			0	1.6					4.6	15.0							0.3	1.5

* All values determined on the basis of 3 replicated observations per field

** Injury values calculated as described in the text.

*** Rated in August, 1978

U - upper leaf surface

L - lower leaf surface

TABLE 9

Severity of Ozone Injury on Norchip Potatoes at Similar Locations in S. Ontario - 1977-1978

County	Location	1977			1978		
		Site No. ( )	Average* % Injury**	Severity Category	Site No. ( )	Average* % Injury**	Severity Category
Wellington	Carlisle	(12)	2.2	T	(1)	0.1	< T
Haldimand-Norfolk	Simcoe	(8)	27.8	M	(16)	19.6	M
Elgin	Pt. Stanley	(6)	4.8	T	(13)	3.6	T
Essex	Leamington	(4)	4.1	T	(11)	2.4	T
Lambton	Thedford	(18)	0.5***	< T	(7)	< 0.1***	< T

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

*** Norchip variety unavailable at this site, injury assessment on Kennebec.

TABLE 10

Severity of Ozone Injury on Flue-Cured and Burley Tobacco in S. Ontario
August, 1977

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Field Planting Date	*Average % Foliar Injury**					
			Flue-Cured		Burley			
			Virginia 115	Delhi 76	Kentucky 2110	Harwin	Burley	Black (chewing)
1	6 km W Drumbo	May 24	0.3					
2	3 km SE Mt. Brydges	May 24	0.6					
3	3 km NW Mt. Brydges	May 24	0.6					
4	3 km ESE Bothwell	May 24	3.6					
5	1 km W Kent Bridge	June 10			0.3	0.7		
6	2 km W Cedar Springs	May 24			3.4			
7	8 km E Pt. Alma	May 18			3.0			
8	2 km W Pt. Alma	May 24			2.3			
9	3 km NE Leamington	May 20			8.8			

(Table 10 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Field Planting Date	*Average % Foliar Injury**					
			Flue-Cured		Burley			
			Virginia 115	Delhi 76	Kentucky 2110	Harwin	Burley	Black (chewing)
10	1 km S Ruthven	May 22			3.3			
11	4 km E Jeannettes Creek	May 26						
12	2 km E Paincourt	June 10				1.6		
13	5 km NE Tupperville	May 26						0.8
14	4 km NNE Blenheim	May 22				3.4		
15	3 km NE Morpeth	June 4				2.0		
16	2 km NE Muirkirk	May 30					0.6	
17	2 km E Rodney	May 26	4.0					
18	4 km NW Pt. Stanley	May 24	4.4					
19	8 km E Pt. Stanley	May 20	20.0					

(Table 10 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Field Planting Date	*Average % Foliar Injury** Flue-Cured Virginia 115	Delhi 76	Kentucky 2110	Burley Harwin	Burley	Black (chewing)
20	1 km W Pt. Bruce	June 1	9.9					
21	3 km NW Pt. Burwell	May 25	4.6					
22	1 km W Houghton	June 9	6.0					
23	1 km W Normandale	May 20	6.8					
24	3 km W Simcoe	May 30	1.9					
25	1 km S Delhi	May 22	0.4					
26	1 km S Tilsonburg	May 25		.5				
27	3 km SE Norwich	May 25	1.4					
28	3 km S Norwich	June 5		0.4				

(Table 10 continued)

Site No.	Approximate Distance and Relative Direction from the Nearest Village, Town or City	Approximate Field Planting Date	*Average % Foliar Injury**					
			Flue-Cured		Burley			
			Virginia 115	Delhi 76	Kentucky 2110	Harwin	Burley	Black (chewing)
29	2 km W Scotland	June 6	0.2					
30	1 km NE Cathcart	May 26	0.4					
31	1 km SE Kendal	May 16	1.7					
32	6 km SE Tyrone	May 26	1.3					
33	3 km N Glencairn	May 24	0.3					

* All values determined on the basis of 3 replicated observations per field.

** Injury values calculated as described in the text.

TABLE 11

Muck Crop Assessment Survey - 1977

Marsh	Grower	Date(s) Visited	Vegetable Crops Examined (approximate planting dates)
Bradford	Mr. Czikai	July 25	Onions (April 20)
	Mr. Jagodics	June 24, July 25	Carrots (April 20) (July 15)
		August 12	Celery (April 20) (July 6)
			Lettuce (May 4) (July 12)
			Onions (April 20)
	G. Verkaik	"	Celery (planted from May 10 on)
			Lettuce (planted from early May on)
			Onions (April 20)
Erieau	C. B'llazukiewicz	July 27	Celery (June 4)
	H. Haubchic	July 27	Onions (April 14)
	Mrs. R. Veermere	June 17, July 27	Onions (April 16) Spinach (April 28)
	Mr. Vlasschaert	July 27	Carrots (May 20) (June 19) Onions (April 20)
	Z. Zorankin	June 17	Carrots (April 16) (May 9)
Pt. Pelee	Gressinger & Son Farms	June 16, July 27	Radish (June 2) (July 5) (July 8)
	W.S. Setterington (Leamington)	June 16	Beets, Brocolli, Cabbage, Carrots, Chard, Onions, Peppers, Spinach, (All crops planted May 20-24)
	Mr. Tatomir	June 16, July 27	Onions (April 15) (May 2)
	K. Wigle (Leamington)	June 16	Cucumber
Thedford	Mr. Kelders (Klondike)	June 14, July 26	Lettuce (May 4), Onions (April 28)
	S. Kwarchuk (Grand Bend)	June 14, July 26	Celery (June 2), Onions (April 26)
	H. Lauchman (N. Marsh)	July 26	Onions (May 1)
	B. Pachlars (Grand Bend)	July 14, July 26	Onions (April 26) (May 12)
	M. Sirokos (Grand Bend)		Carrots (April 26) Celery (June 1) Onions (May 2)

TABLE 12

Comparison of Ozone Episodes at Simcoe During the Various Periods of Potato Growth and Sensitivity 1976-1978

	Number of Hours with Ozone in Excess of 100 parts per billion				Number of Days Ozone Levels Exceed 100 ppb for 4 consecutive hours			
Year	June 1-15	June 16-30	July 1-15	July 16-31	June 1-15	June 16-30	July 1-15	July 16-31
1976	27	6	2	1	3	0	0	0
1977	2	13	5	11	0	2	1	2
1978	5	1	8	22	1	0	1	3

TABLE 13

Summary of Statistics of Ozone Monitored at Four Locations in Ontario, in 1976, 1977, and 1978, During June, July, and August

Location	Year	Ambient Ozone Levels (parts per billion) Mean Hourly Concentration	Maximum Hourly Concentration	No. of Hourly Values > 80 ppb
Huron Park (#10001)	1977	39.3	117	83
	1978	35.9	130	122
Merlin (#13021)	1977	49.2	167	200
	1978	38.1	132	130
Simcoe (#22071)	1976	44.9	139	238
	1977	48.1	133	148
	1978	44.5	132	183
Stouffville (#48002)	1976	41.4	163	120
	1977	33.0	152	33
	1978	42.5	120	134

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ASSESSMENT OF OZONE AND PAN-TYPE INJURY TO TOMATO AND POTATO PLANTINGS IN SOUTHERN ONTARIO: 1979

Ozone and PAN-type injury surveys have been conducted annually on the above crops since 1972 and 1977, respectively. The primary objectives of the 1979 surveys were threefold:

(1) to document the severity of injury on tomato and potato plantings across the province

(2) to document the patterns of foliar injury development on affected tomato and potato plants and

(3) to examine varietal sensitivity or resistance to symptom development under ambient field conditions.

Contrary to previous years' tomato and potato surveys, which entailed transversing the central and southwestern parts of the province and evaluating injury on randomly selected plantings near major roadways, the locations of sites visited in 1979 were restricted mainly to the primary growing areas in southwestern Ontario. Consequently, the number of sites visited in 1979 was reduced, and more varieties generally were examined, compared to other years.

In 1979, tomato plantings were examined in field plots of the major canning companies in the following areas: Leamington (H.J. Heinz Co.), Tilbury (Hunt-Wesson), Chatham (Campbell Soup Ltd. - Libbys'), Dresden (Canadian Canners) and Streetsville (Campbell Soup Ltd.). Tomato

variety trials at the Horticulture Research Station in Simcoe also were examined. Potato plantings were evaluated at the same locations visited in 1978.

In 1979, as in 1977 and 1978, tomato and potato plants at each location were randomly selected and all rateable compound leaves on the main vine and/or one on two of the main off-shoots were examined for foliar injury development. The average injury to the undersurface of the leaves for each plant was calculated using the formula $(\frac{B}{A} \times C)$ *where:*

- A — *The total number of true compound leaves examined.*
- B — *The total number of true compound leaves examined exhibiting injury.*
- C — *Average % injury to all affected leaves examined.*

However, contrary to previous years' potato surveys, oxidant injury to potato plants, characterized by adaxial stippling was not formally calculated but only generally assigned a representative percentage injury value. The pattern of abaxial foliar injury development on affected tomato and potato plants, unlike previous years, was reproduced on pre-sketched drawings of compound leaves on a formal evaluation sheet prepared separately for each crop prior to the surveys.

During the surveys, samples of tomato and potato leaves manifesting lower surface injury were collected for histological examination as well as for the herbarium.

Tomato and potato surveys were conducted at the end of June and during mid-July, respectively, when most tomato and potato plants generally were flowering. All site locations visited during the surveys are shown on

the attached figure. The severity of injury evaluated on all tomato and potato varieties examined in 1979 is shown in Tables 1 and 2, respectively. A partial summary of the surveys is shown below:

Crop	No. of Sites Visited	No. of Varieties Examined	No. of Plants Examined	No. of Examined Plants Injured	Ave. No. of Compd. Lvs. Examined /Plant	Ave. No. of Examined Compd. Lvs. Injured /Plant
Tomato	7	32	129	74	6-8	2-5
Potato	10 (7 general areas)	11	81	64	9-10	4-7

The predominant injury observed on affected plants of both crops consisted of silver grey-rustic coloured, small (< 1-2 mm), irregular sized interveinal lesions on the undersurface of the leaves. The injury was confined at or near either the tip, base or margins, or scattered over the entire undersurface of the affected leaflets. In some instances the lesions had coalesced and induced bifacial injury. It also appeared that the silver grey coloured lesions were more symbolic of recent injury than the rustic coloured lesions which were confined usually to the oldest leaves, the ones most likely to be injured early in the season. The symptoms observed on affected tomato and potato plants were confined mostly to the middle and lower positioned leaves. On plants where some pattern of foliar injury development was detected the injury to any single affected leaflet usually was observed at the same location on the lateral adjoining leaflet. On tomatoes, approximately 80% of the total number of plants examined exhibited some pattern of foliar injury development.

Average injury on all examined tomato and potato varieties in 1979 was in the < 1-8% range. The most severely injured tomato and potato varieties observed at each location are underscored in Tables 1 and 2, respectively. Based on the severity of injury to corresponding tomato and potato varieties evaluated at similar locations during 1978 and 1979, PAN-type injury to tomatoes in the Leamington and Chatham areas was similar to or slightly less in 1979 than in 1978, and injury at Dresden and Simcoe in 1979 was either similar to 1978 or found to be more severe.

Ozone injury to potatoes at Ridgetown, Thedford, Cambridge, Simcoe and Bradford was found to be similar to or slightly less in 1979 than in1978, and at Port Stanley and Cambridge in 1979 the injury was generally more severe, compared to the previous year.

Also, in 1979 upper leaf surface stippling, in the < 1-2.5% range, was observed on sensitive potato varieties near Thedford (Cheftain; Kennebec), Ridgetown (Norland), Pt. Stanley (Norchip), and Bradford (Cheftain). Injury of this nature was most severe at Bradford and Pt. Stanley. Of the above four locations stippling in 1978 only was observed at Bradford.

In general, the histological findings confirmed that the primary injury observed on affected tomato and potato plants was typical of that induced either by ozone or in the case of tomato was PAN-like in nature.

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Attach.

PH/35/6

'Figure - Southern Ontario map showing the location of all tomato and potato sites visited in 1979

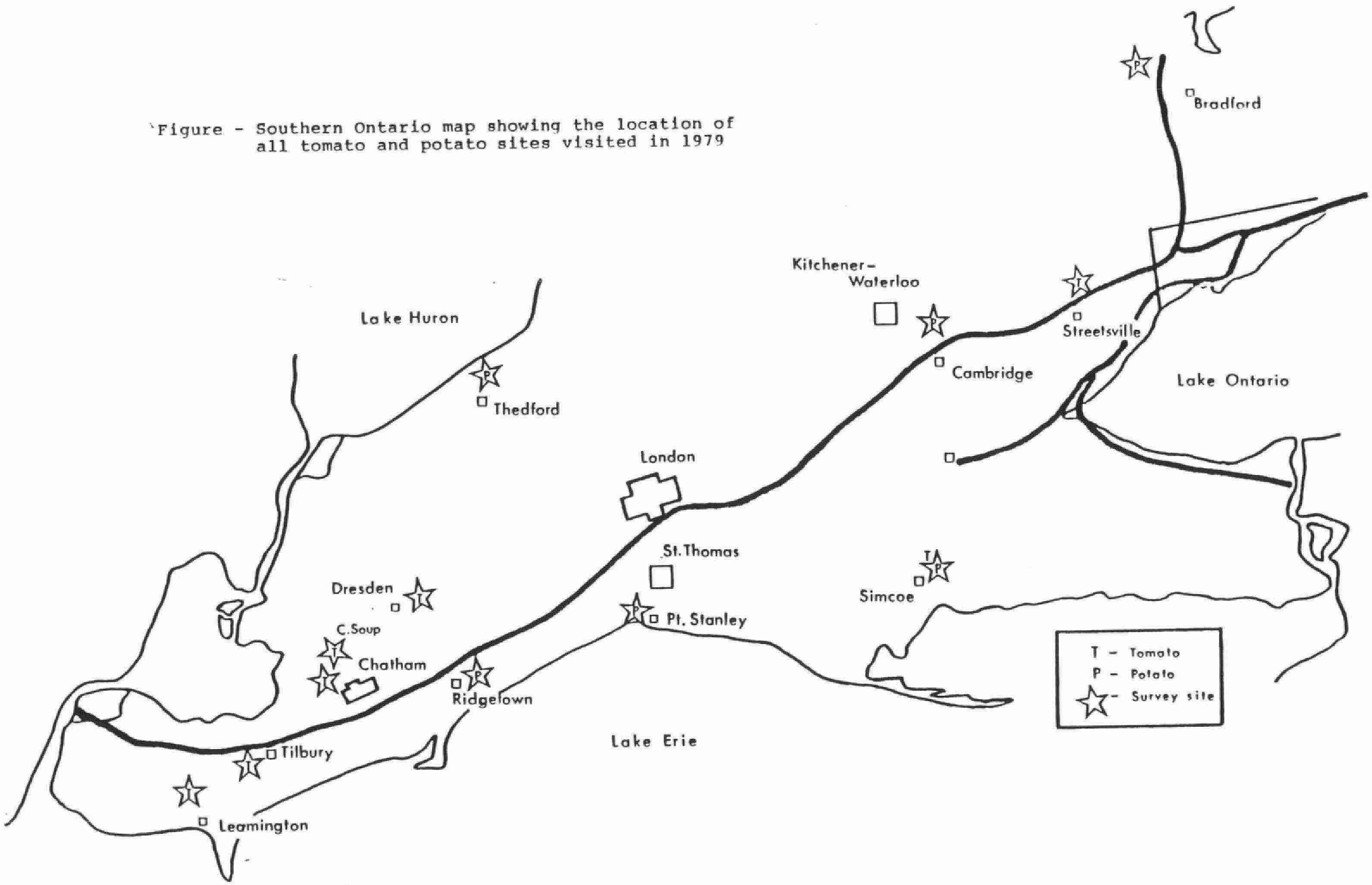

TABLE 1

PAN-type Injury Evaluated on Tomato Plantings in Central and Southwestern Ontario - June, 1979

Varieties Examined	Co. Location	Campbell Soup Ltd.		Canadian	H.J. Heinz Co.	Hunt-Wesson	Libby's	Hort. Res. Station
		Chatham	Streetsville	Dresden	Leamington	Tilbury	Chatham	Simcoe
				*Average % Injury - Undersurface of the Leaves				
C[illegible]		< 1.0	6.0	< 1.0	< 1.0		< 1.0	5.5
C-35			< 1.0					
C-37		0	6.0					< 1.0
C[illegible]			2.0					
C.C. 7101				0				
C[illegible] 7102				< 1.0				
C[illegible]. 7145				< 1.0				
C.X. 791		0						
C[illegible]o III					0			2.5
H-300						0		
H[illegible]18					0			
H[illegible]350				2.0			< 1.0	
H-1409					0			
H[illegible]630					< 1.0			
H[illegible]706					< 1.0			
H-2653		< 1.0	8.0					1.0
H[illegible]653(a)					< 1.0			
H-2653(b)					1.5			0
H[illegible]867					< 1.0			
H[illegible]919					0			
Hunts 134						< 1.0		
H[illegible]ts 208F					< 1.0	< 1.0		
Libby 7241							1.5	0
New Yorker				1.5	< 1.0	< 1.0		< 1.0
[illegible]. 771				< 1.0	0			0
Ont. 777					< 1.0			
[illegible]. 7616		< 1.0						
[illegible]awa 78				3.5				
Pet o 80					< 1.0			
[illegible]ma V.F.								1.0
Veemore								7.0
Veepro							2.0	

* The average % foliar injury of all plants evaluated for each variety.

Indicates the most sensitive variety of varieties observed at each location where apparent injury differences between the varieties were detected.

TABLE 2

Ozone Injury Evaluated on Potato Plantings in Central and Southwestern Ontario - July, 1979

Location		Chieftain	Kennebec	Katahdin	Netted Gem	Norchip	Norland	Oneida	Red Pontiac	Sebago	Superior	Tobique
		Varieties Examined										
		*Average % Injury - Undersurface of the leaves										
Pt. Stanley	(1)					8.0***				4.0	< 1.0	
Ridgetown	(1)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2.0		< 1.0		< 1.0	
Thedford	(2)	< 1.0	< 1.0	< 1.0								
Cambridge	(2)	< 1.0	1.0	2.5						< 1.0	< 1.0	
Simcoe	(1)		< 1.0		< 1.0	< 1.0		< 1.0			2.0	< 1.0
Alliston	(2)					0					0	
Bradford	(1)	< 1.0										

( ) No. of sites visited.

* The average % foliar injury of all plants evaluated for each variety.

** Norchip were transplanted on June 11; Sebago and Superior went in about May 8.

— Indicates the most sensitive variety or varities observed at each location where apparent injury differences between the varieties were detected.

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ASSESSMENT OF OZONE INJURY ON POTATO AND TOMATO PLANTINGS ACROSS SOUTHERN ONTARIO: 1980 AND 1981

Assessment surveys to determine the severity of ozone injury to potato and tomato plantings across Southwestern and Central Ontario were conducted by the writer and R. Pearson during 1980 and 1981. Phytotoxicology surveys on these crops have been conducted annually since 1972 and 1977, respectively.

In contrast to previous years, when potato and tomato crops were assessed on separate occasions during the growing season, during 1980 and 1981 the two surveys were combined and conducted during early July. This was about the time potatoes were surveyed in other years; tomatoes in the past usually were assessed at the end of June.

During early July in 1980 and 1981, potato and tomato plants growing in varietal and experimental field plots as well as in commercial growers' fields in the primary growing areas were examined for unusual injury. During both years, potato or tomato plants or both were assessed for injury at the following nine locations: Thedford, Reece's Corners, Harrow, Ridgetown, Port Stanley, Simcoe, Cambridge, Kettleby and Alliston. Tomatoes also were assessed at Port Rowan and in University of Guelph (U of G) research plots at Harrow, Charing Cross and Simcoe during 1980 and at Harrow, Simcoe and Cambridge during 1981. Potato plants also were examined during 1981 in U of G research plots at Simcoe, Alliston and Burlington. Overall, during the two years, nineteen potato and twenty four tomato varieties were assessed. Generally, more varieties of both crops were examined in 1981.

During the surveys, the plant or plants assessed at each location were selected at random and the average percent injury to the upper and lower foliar surface of each plant was determined. This was accomplished by examining all true or rateable compound leaves on each plant/vine and visually estimating the average percent injury to each affected leaf and then calculating the overall foliar injury to the plant based on the number of leaves examined. In cases where upper and lower surface injury was present on the same leaf the two estimates were summed to provide the rating for the leaf.

Also, during the survey, tomato plants that had been treated (biweekly foliar sprays with antiozonant EDU and (untreated) Bel W_3 tobacco plants growing in U of G tomato plots were examined. Potato and/or tomato leaves displaying typical or atypical ozone injury symptoms or both were collected at Harrow and Alliston during 1980, and at Simcoe and Cambridge during 1981, for histological examination.

During the final week in July, 1981, potato plants at Simcoe, Cambridge, Alliston and Kettleby were re-examined for injury. Several potato cultivars also were examined in the U of G Burlington plot located near the intersection of QEW and Bronte Road.

The severity of ozone injury observed on each crop at all locations in early July during both 1980 and 1981 and on potatoes during late July, 1981 is shown in attached Tables 1 and 2.

Generally, the foliar symptoms observed during 1981 were similar to the injury symptoms observed on affected potato and tomato plants during 1980 and in previous years. The injury symptoms displayed by affected potato plants were characterized by (1) upper leaf surface stippling, which is typical of ozone injury to potatoes, and (2) under leaf surface, grey-rust, coloured lesions (Photograph 1). The later injury type

(2), which also was observed on tomato plants on the underside of the leaves (Photograph 2), is atypical of ozone injury to both crops based on descriptions of ozone injury reported on these crops in the literature.

Both the under leaf surface lesions and banding pattern of atypical injury observed on the compound leaves of more severely affected plants resembled the documented effects of PAN on tomatoes. However, research conducted by the Phytotoxicology Section in a separate study at Simcoe has revealed that PAN is not involved and that the atypical symptoms are most likely a reaction to ozone. This conclusion was supported by the histology results which revealed the under leaf surface lesions to be characteristic of tissue damage resulting from plant exposure to ozone.

During 1980, ozone injury was observed at all locations except Reece's Corners and Ridgetown with the most severe injury being observed on the more severely affected potato and tomato varieties (Norland (27.0%) and Heinz 2653 (3.5%), respectively) at Harrow. The average severity of foliar plant injury observed on all other injured potato and tomato cultivars examined during 1980 ranged from less than 1.0 to 4.5% (Tables I and 2).

During early July in 1981, ozone injury was observed at all locations except Alliston and Kettleby. The most severe injury was observed on the Superior potato cultivar (1.3%) and on Heinz 2653 tomato plants (1.0%) at Harrow and Cambridge, respectively. All other affected potato and/or tomato plants examined at these and at all other sites during early July in 1981 displayed less than 1.0% foliar injury.

Observations made during 1980 and 1981 in U of G tomato plots generally revealed the EDU treated tomato plants to be less severely injured than untreated plants. Bel W_3 tobacco indicator plants which were growing in tomato plots at Harrow, Charing Cross and Simcoe in 1980, and at Harrow, Simcoe and Cambridge in 1981, during early July of both years

displayed typical ozone injury symptoms. During both years, tobacco plants at Harrow were most severely injured with older leaves displaying as much as 50% foliar injury in 1980 and 10% injury in 1981.

During the final week of July in 1981, ozone injury to potato plants was slightly more severe at three of the four potato planting sites that were revisited (Simcoe, Cambridge and Alliston) with more varieties generally exhibiting injury than in early July. On July 30th, extremely senitive Norland plants at Cambridge displayed as much as 20% foliar injury.

Also, during the final week of July in 1981, the assessment of 13 potato cultivars at the Bronte Road (Burlington) plot revealed Norchip to be the most severely injured while Cherokee and Campbell 13 were 2nd and 3rd most severely affected. Norlands at this site displayed less than 1.0% foliar injury which was similar to the severity of injury exhibited by both Norlands and Norchips growing at Simcoe and Alliston at the end of July (1981).

A comparison of the corresponding 1980 and 1981 average foliar ozone injury values (final column in Tables) for both crops generally revealed the injury to potatoes at Ridgetown and Port Stanley, to be slightly more severe; at Harrow, Thedford, Kettleby and Alliston to be about the same; and at Simcoe to be slightly less severe, during 1981. On tomatoes, during 1981, injury at Reece's Corners and Ridgetown was slightly more severe; and at Harrow and Simcoe was slightly less severe, than in 1980.

The injury displayed by both crops during both 1980 and 1981 generally was less severe than that observed on tomato and potato crops in 1972 and 1977 when respective province wide surveys were first conducted by this section. Ozone injury to tomato crops ranged from $<$ 1.0 to 35 percent in 1972 whereas potato crops displayed foliar injury in the $<$ 1.0 to 26.0 percent range in 1977.

Presented on attached Table 3 is a summary showing at eight locations in Ontario the number of occasions ambient ozone levels at or exceeding 80 ppb for one or more consecutive hours were recorded in 1980 and 1981 during June and July. All corresponding hourly ozone plots are attached for reference.

As Table 3 shows, there were numerous occasions during both years when ambient ozone at or exceeding the Ministry criterion of 80 ppb was monitored across Ontario.

A comparison of the two years' corresponding June results revealed more days and hours with 80 ppb or more ozone recorded at Huron Park, Petrolia, London and Simcoe, and fewer days and episodes or hours when this level was recorded or exceeded at Windsor, Merlin and Kitchener during 1981.

Also, a comparison of each year's corresponding June and July data revealed that during both years there generally were more days and hours with high ozone or potentially plant injurious episodes experienced during July. This finding probably accounts for the increase in injury severity that was observed at three of the four potato planting sites that were revisited during late July in 1981.

An ozone injury assessment survey on both crops will be repeated during 1982.

R.N. EMERSON
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Vegetation Assessment Unit
Phytotoxicology Section

RNE/hm

Attach.

PH/24

TABLE 1:

Severity of Ozone Injury to Potato Plantings across Southwestern and Central Ontario-July 1980 & 81.

Location	Assessment Date 1980	Assessment Date 1981	Variety	Most Severely Affected Leaf 1980	Most Severely Affected Leaf 1981	Percent Foliar Injury No.of Injured leaves(lvs)-Total of % Inj. Values for all Inj.lvs. 1980	Percent Foliar Injury 1981	Average Injury of All leaves on Plant/Vine 1980	Average Injury 1981
Harrow	July 7	July 6	Jemseg	1.0	1.5	7-4.5	5-3.5	0.6	0.3
			Kennebec		-		0		0
			Norland	31.0		8-217.0		27.0	
			Superior	-	7.0	0	7-13.0	0	1.3
Thedford	July 8	July 7	Cheiftain	0.5	0.5	1-0.5	2-1.0	0.1	0.1
			Katahdin	1.0	0.5	5-4.0	2-1.0	0.4	0.1
			Kennebec	-	-	0	0	0	0
			Netted Gem		-		0		0
			Superior		-		0		0
Ridgetown	July 7	July 6	Belleisle		-		0		0
			Cheiftain	-	-	0	0	0	0
			Jemseg		-		0		0
			Katahdin	-	-	0	0	0	0
			Kennebec	-	1.0	0	1-1.0	0	0.1
			Netted Gem	-	-	0	0	0	0
			Norchip	-	1.5	0	2-2.0	0	0.2
			Norland	-	2.0	0	4-5.5	0	0.7
			Sebago		-		0		0
			Superior	-	0.5	0	1-0.5	0	0.1
			Yukon Gold		1.0		2-2.0		0.2
Port Stanley	July 8	July 7	Kennebec	0.5	-	6-3.0	0	0.4	0
			Norchip	-	0.5	0	5-2.5	0	0.2
			Superior	-	1.0	0	3-2.0	0	0.4
Simcoe	July 9	July 3 (July 31)	Beirus		-		0		0
			Campbell 13		- (-)		0 (0)		0 (0)
			Cheiftain		-		0		0
			Cherokee		1.0		1-1.0		0.1
			Jemseg	2.0		6-7.0		0.7	
			Katahdin		-		0		0
			Kennebec	7.5	- (0.5)	11-50.0	0 (3-1.5)	4.5	0 (0.2)
			Monona		- (0.5)		0 (4-2.0)		0 (0.2)
			Netted Gem	-	(0.5)	0	(2-1.0)	0	(0.1)
			Norchip	9.0	- (1.0)	9-24.5	0 (2-1.5)	2.7	0 (0.1)
			Norland		0.5 (2.0)		2-1.0 (5-4.0)		0.1 (0.4)
			Rideau		- (0.5)		0 (2-1.0)		0 (0.1)
			Sebago		-		0		0
			Superior	1.0	-	5-3.0	0	0.3	0
			Yukon Gold		- (0.5)		0 (2-1.0)		0 (0.1)
Cambridge	July 8	July 7 (July 30)	Beirus		- (5.0)		0 (10-11.0)		0 (0.8)
			Cheiftain	0.5		1-0.5		0.1	
			Jemseg	-	- (2.0)	0	0 (3-3.5)	0	0 (0.7)
			Kennebec	0.5	(2.0)	3-1.5	(5-4.0)	0.2	(0.5)
			Norchip	0.5	(10.0)	1-0.5	(5-17.0)	0.1	(2.4)
			Norland	0.5	1.0 (30.0)	1-0.5	7-5.0(6-118.0)	0.1	0.5 (20.0)
			Oceana		- (-)		0 (0)		0 (0)
			Rideau		0.5 (-)		2-1.0 (0)		0.1 (0)
			Superior	-	0.5 (-)	0	1-0.5 (0)	0.	0.1 (0)
			Yukon Gold		0.5 (1.0)		1-0.5 (2-1.5)		0.1 (0.3)
Burlington (QEW-Bronte Rd.)		July 31	Atlantic		2.0		11-6.0		0.5
			Beirus		1.0		4-2.5		0.2
			Campbell 13		4.0		11-17.0		1.4
			Cheiftain		1.0		10-6.5		0.5
			Cherokee		3.5		11-20.0		1.7
			Kennebec		1.0		9-6.0		0.5
			Monona		1.0		5-3.0		0.3
			Netted Gem		0.5		1-0.5		0.04
			Norchip		7.0		11-33.0		3.0
			Norland		1.0		5-4.0		0.6
			Rideau		0.5		3-1.5		0.2
			Sebego		1.0		6-4.0		0.3
			Yukon Gold		1.0		7-4.0		0.4
Kettleby	July 9	July 8 (July 30)	Beirus		- (-)		0 (0)		0 (0)
			Chieftain	-	- (-)	0	0 (0)	0	0 (0)
			Jemseg	0.5	- (-)	1-0.5	0 (0)	0.1	0 (0)
			Kennebec	-	- (-)	0	0 (0)	0	0 (0)
			Netted Gem	0.5	- (-)	1-0.5	0 (0)	0.1	0 (0)
			Norchip	-	- (-)	0	0 (0)	0	0 (0)
			Rideau		- (-)		0 (0)		0 (0)
			Superior	-	- (-)	0	0 (0)	0	0 (0)
			Yukon Gold		- (-)		0 (0)		0 (0)
Alliston	July 9	July 8 (July 30)	Cheiftain		(1.0)		(12-7.5)		(0.6)
			Kennebec		(0.5)		(5-2.5)		(0.2)
			Monona	1.0		3-2.0		0.2	
			Norchip	-	- (0.5)	0	0 (2-1.0)	0	0 (0.1)
			Norland		(0.5)		(5-2.5)		(0.3)
			Superior	-	-	0	0	0	0

TABLE 2

Severity of Ozone Injury to Tomato Plantings across Southwestern and Central Ontario - July 1980 and 1981.

Location	Assessment Date 1980	Assessment Date 1981	Variety	Most Severely Affected Leaf 1980	Most Severely Affected Leaf 1981	Percent Foliar Injury No. of Injured leaves(lvs)-Total of % Inj. Values for all Inj.lvs. 1980	Percent Foliar Injury No. of Injured leaves(lvs)-Total of % Inj. Values for all Inj.lvs. 1981	Average Injury of All leaves on Plant/Vine 1980	Average Injury of All leaves on Plant/Vine 1981
Harrow	July 7	July 6	Campbell 19		1.0		3-2.0		0.2
			Campbell 28	1.0	0.5	5-2.0	1-0.5	0.2	0.1
			Crimson V		-		0		0
			Early Detroit		-		0		0
			Heinz 1350		-		0		0
			Heinz 1706	20.0	-	6-41.5	0	3.0	0
			Heinz 2653	14.0	-	8-41.5	0	3.5	0
			New Yorker	17.0	1.0	4-37.5	5-3.0	3.1	0.3
			Springset		-		0		0
			Star Shot		-		0		0
			Veemore	15.0	-	6-42.5	0	3.0	0
			Veepro	16.0		4-27.0		1.8	
Reeces' Corners (N. of Wyoming)	July 8	July 7	Heinz 1350		0.5		1-0.5		0.1
			Jackpot		0.5		2-1.0		0.1
			Redpack	-	0.5	0	2-1.0	0	0.1
			Roma		-		0		0
			Springset	-	-	0	0	0	0
Charing Cross	July 7		Campbell 28	1.0		4-2.5		0.3	
			Heinz 1706	3.0		8-10.5		0.7	
			Heinz 2653	6.0		9-24.0		1.7	
			New Yorker	5.0		8-26.5		1.9	
			Veemore	4.0		8-20.0		1.7	
			Veepro	3.0		4-6.0		0.5	
Ridgetown	July 7	July 6	Campbell 28	-	-	0	0	0	0
			Campbell 35	-	-	0	0	0	0
			Campbell 37		1.0		2-2.0		0.3
			Campbell 38	-		0		0	
			Harvestvee		1.0		1-1.0		0.2
			Heinz 1706	-	-	0	0	0	0
			Heinz 2653	-	0.5	0	1-0.5	0	0.1
			Hunt 300	-		0		0	
			New Yorker	-	1.0	0	1-1.0	0	0.1
			Ontario 771	-		0		0	
			Ontario 777		-		0		0
			Ontario 7920	-		0		0	
			Peto 80	-		0		0	
			Quinte	-		0		0	
			Springset	-		0		0	
Port Rowan	July 9		Heinz 1350	2.0		7-6.5		0.5	
			Springset	-		0		0	
Simcoe	July 9	July 9	Campbell 19		0.5		1-0.5		0.1
			Campbell 28	0.5	-	2-1.0	0	0.1	0
			Crimson V		-		0		0
			Early Detroit		-		0		0
			Heinz 1350		-		0		0
			Heinz 1706	-	-	0	0	0	0
			Heinz 2653	3.0	-	3-4.5	0	0.5	0
			New Yorker	0.5	-	1-0.5	0	0.1	0
			Springset		-		0		0
			Starshot		-		0		0
			Veemore	2.0	2.0	5-6.0	9-9.0	0.5	0.8
			Veepro	-		0		0	
Cambridge		July 7	Campbell 19		-		0		0
			Campbell 28		-		0		0
			Crimson V		-		0		0
			Early Detroit		-		0		0
			Heinz 1350		0.5		3-1.5		0.1
			Heinz 1706		-		0		0
			Heinz 2653		5.0		6-10.0		1.0
			NewYorker		-		0		0
			Springset		-		0		0
			Starshot		-		0		0
			Veemore		1.0		6-4.0		0.5

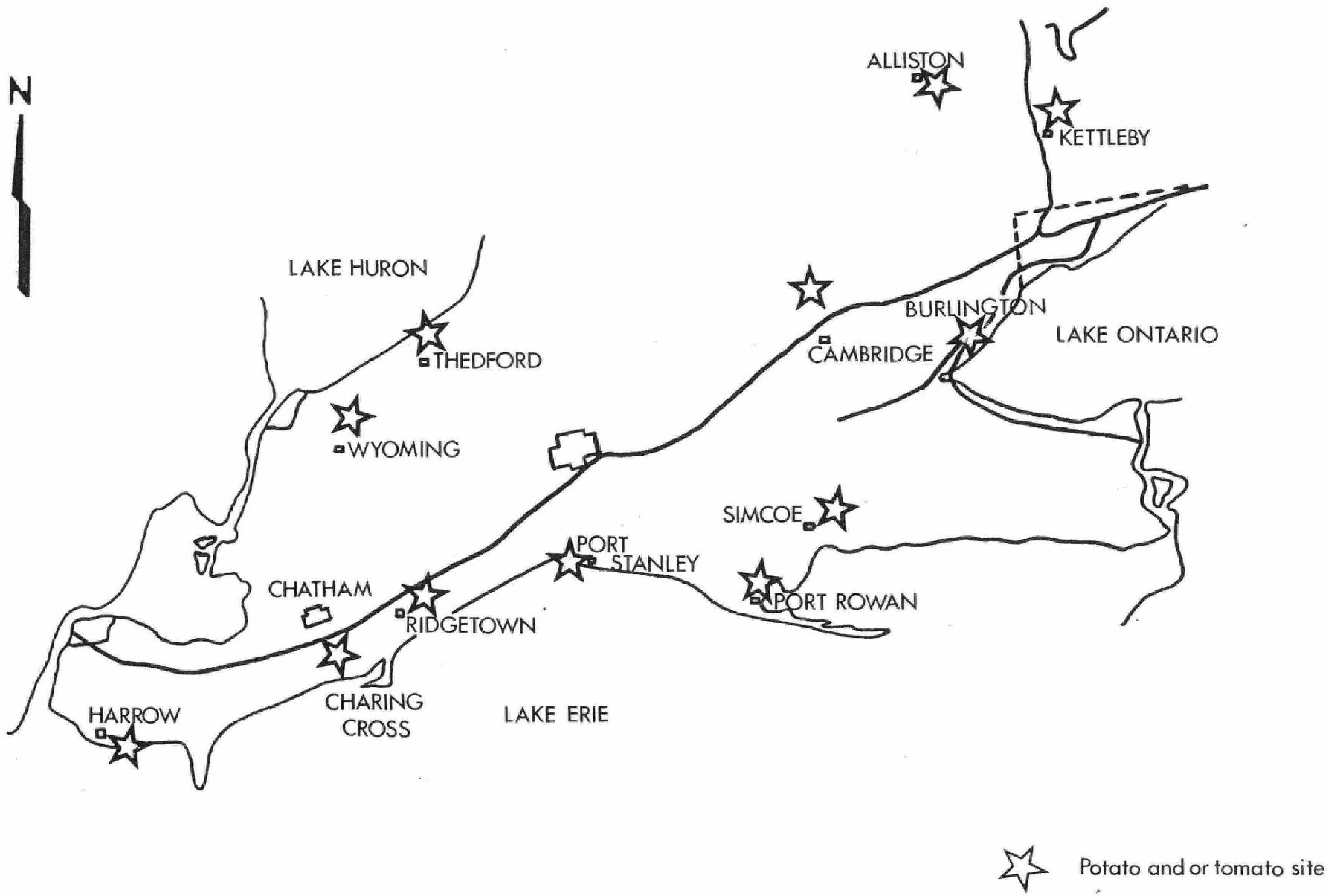
Table 3:
Number of Occasions Ambient Ozone at or above 80 ppb was Recorded at Eight Locations in Ontario during June and July of 1980 and 1981.

Ozone Monitoring Sta. (No.)	Closest Field Survey Site	No. of Consecutive Hours O_3 at or exceeding 80 ppb. 1980 June 1–3	1980 June 4–8	1980 June 8	1980 July 1–3	1980 July 4–8	1980 July 8	1981 June 1–3	1981 June 4–8	1981 June 8	1981 July 1–3	1981 July 4–8	1981 July 8
					SOUTHWESTERN ONTARIO								
Huron Park	Thedford	3	1	0	3	2	0	4	1	1	2	4	2
(10001)			3 (9)*			5 (23)			6 (24)			8 (47)	
Petrolia	Reece's Cors.	5	1	0	1	1	0	2	4	1	8	1	0
(14118)			5 (17)			2 (6)			7 (34)			9 (20)	
Windsor	Harrow	7	1	1	12	6	1	1	1	1	12	3	1
(12008)			8 (33)			15 (63)			3 (15)			12 (42)	
Merlin	Ridgetown	2	2	1	8	3	0	0	0	0	5	3	0
(13021)			5 (24)			9 (29)			(0)			7 (19)	
London	Pt. Stanley	1	2	0	6	2	0	4	3	0	8	2	0
(15001)			3 (17)			6 (23)			6 (22)				6 (24)
					CENTRAL ONTARIO								
Simcoe	Simcoe	4	2	0	1	2	0	4	1	2	5	3	3
(22071)			5 (20)			3 (18)			6 (36)			8 (56)	
Kitchener	Cambridge	3	4	1	3	1	0	2	0	1	4	2	2
(26029)			7 (37)			3 (9)			4 (16)			6 (35)	
**Alliston	Alliston		-			-		0	0	1	2	1	0
(47035)									1 (10)			3 (9)	

* No. of days (hours) during month ozone at or exceeding 80 ppb was monitored in the ambient atmosphere.

** Data only were available for 1981 and in June only were valid for June 26 - 30th.

Figure : Locations Where Potato or Tomato Plantings or Both Were Examined for Ozone Injury During 1980 & 1981.



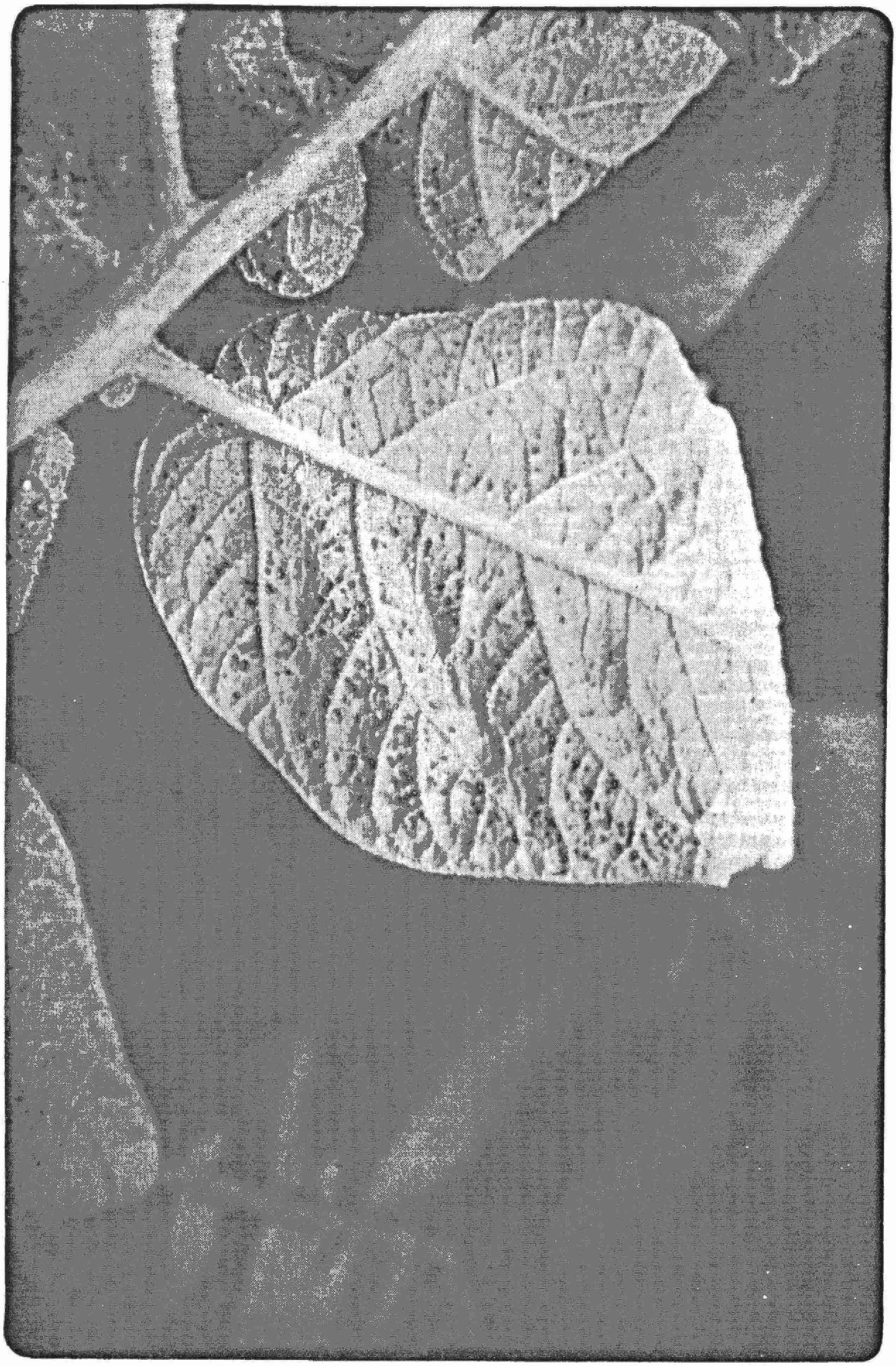
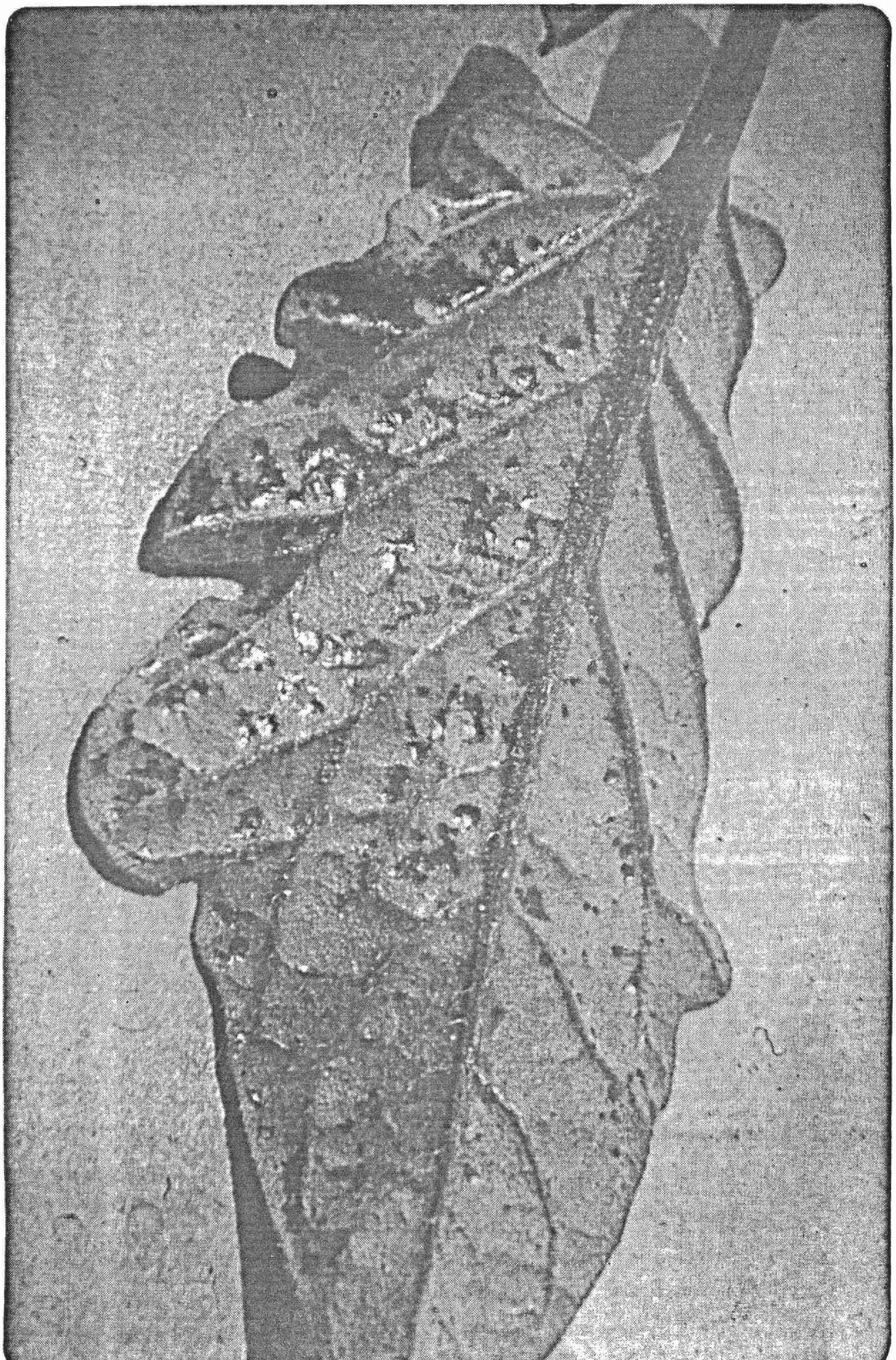
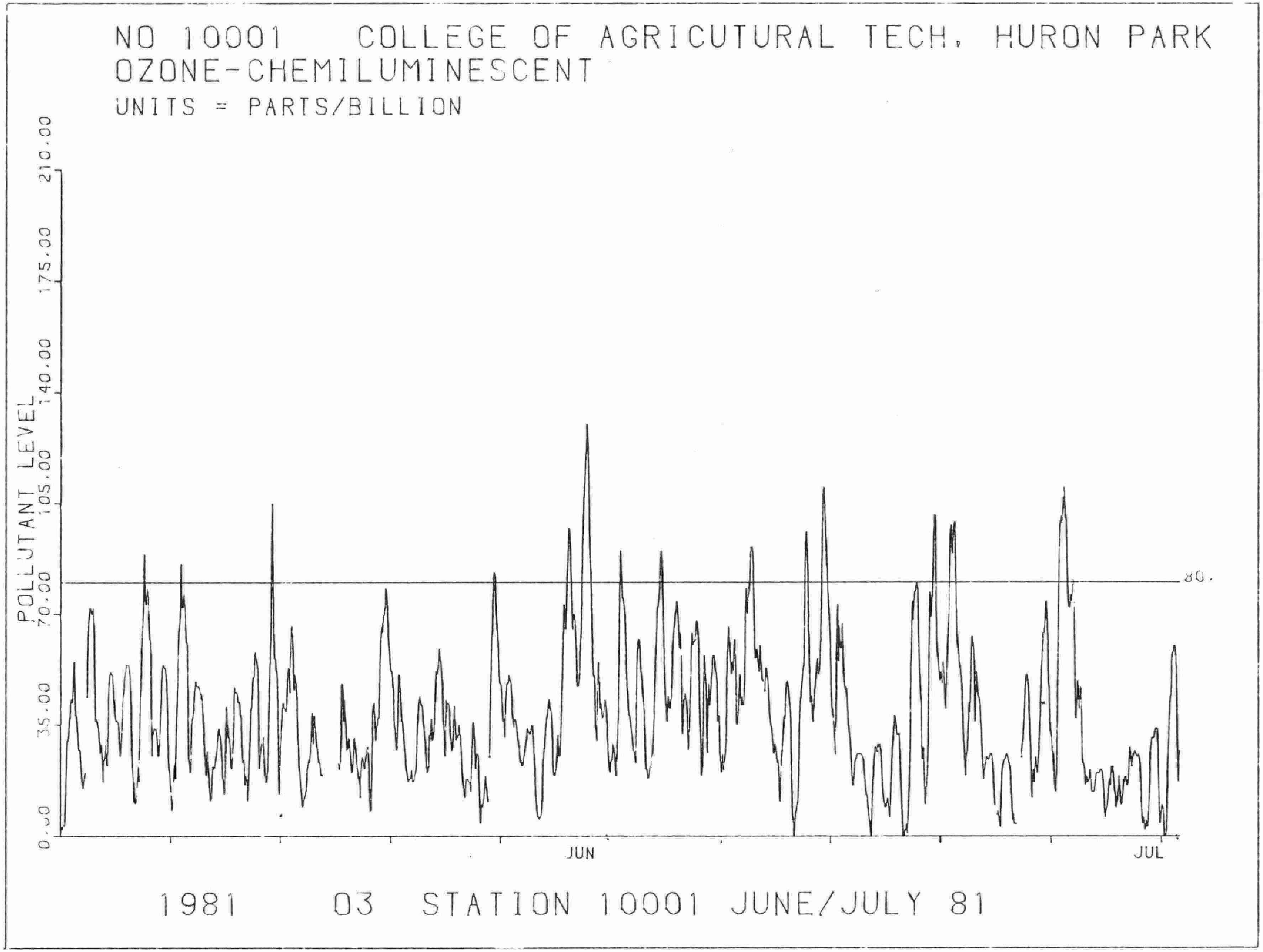


Photo 1: Air Pollution Injury to the Under Surface of Potato Foliage.

Photo 2: Typical Air Pollution Injury Observed on the Lower Surface of Tomato Foliage.

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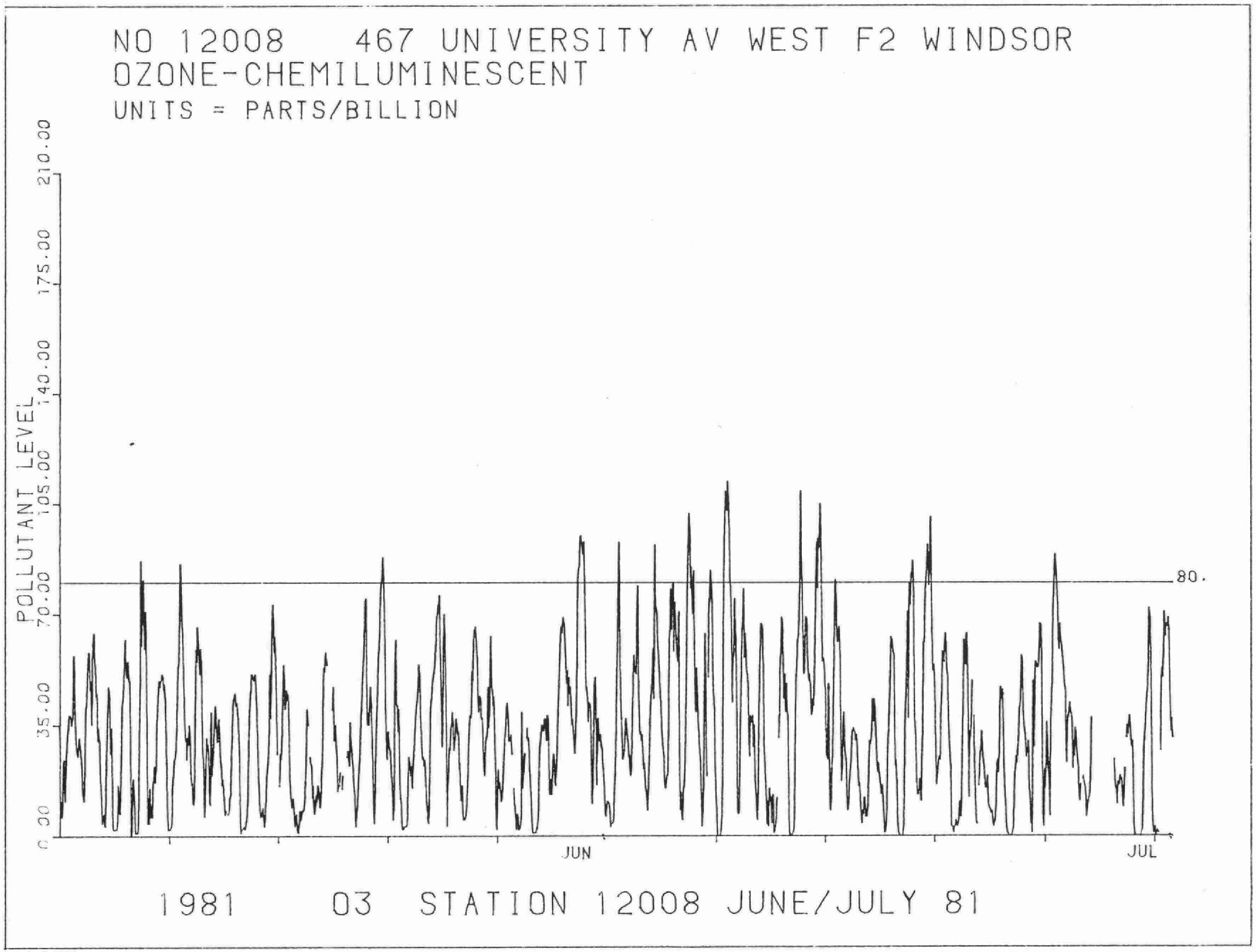
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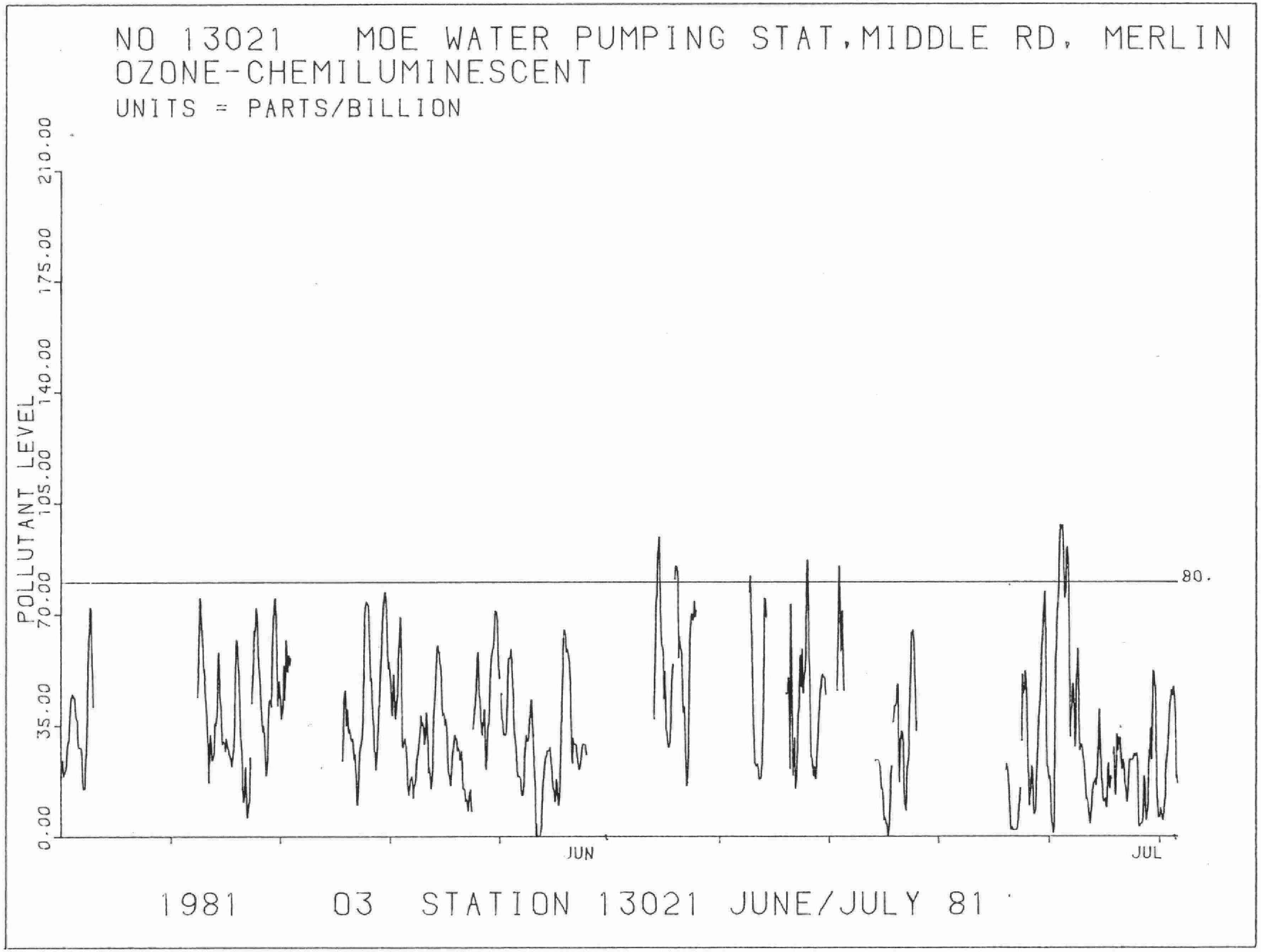

NO 13021 MOE WATER PUMPING STAT,MIDDLE RD, MERLIN
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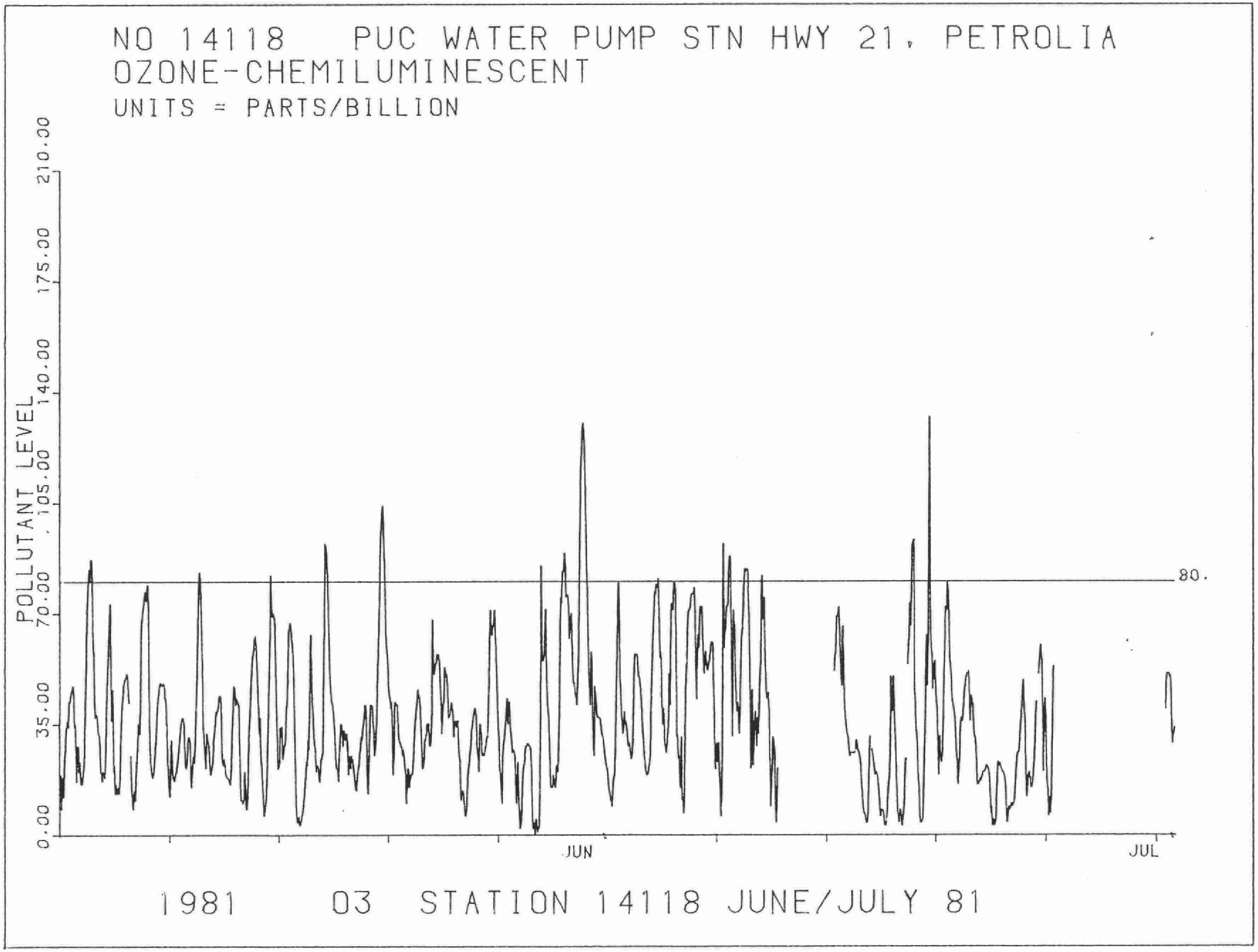
70.00
105.00
140.00
175.00
210.00
80.
JUN
JUL
1981 03 STATION 13021 JUNE/JULY 81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JUL
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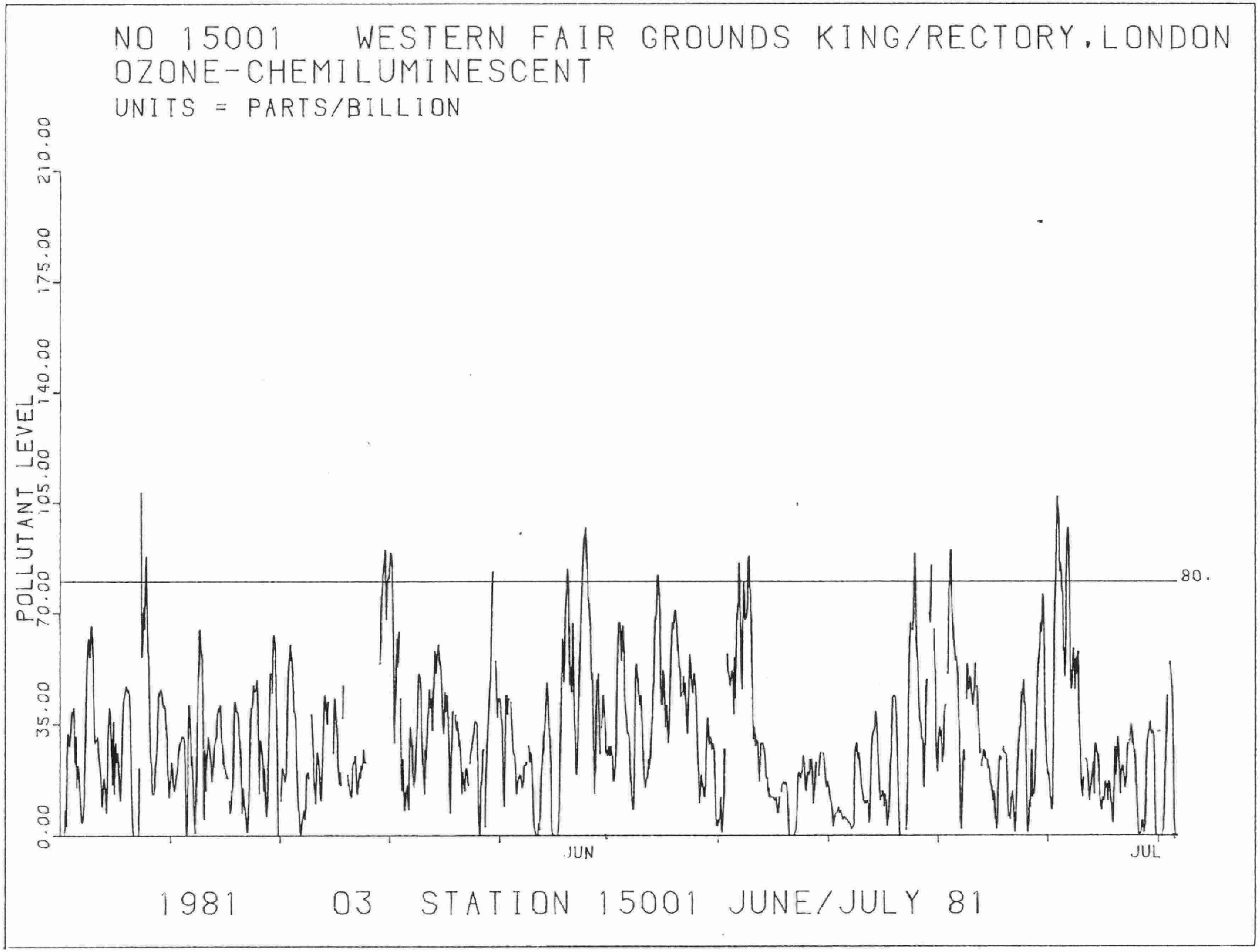
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JUL
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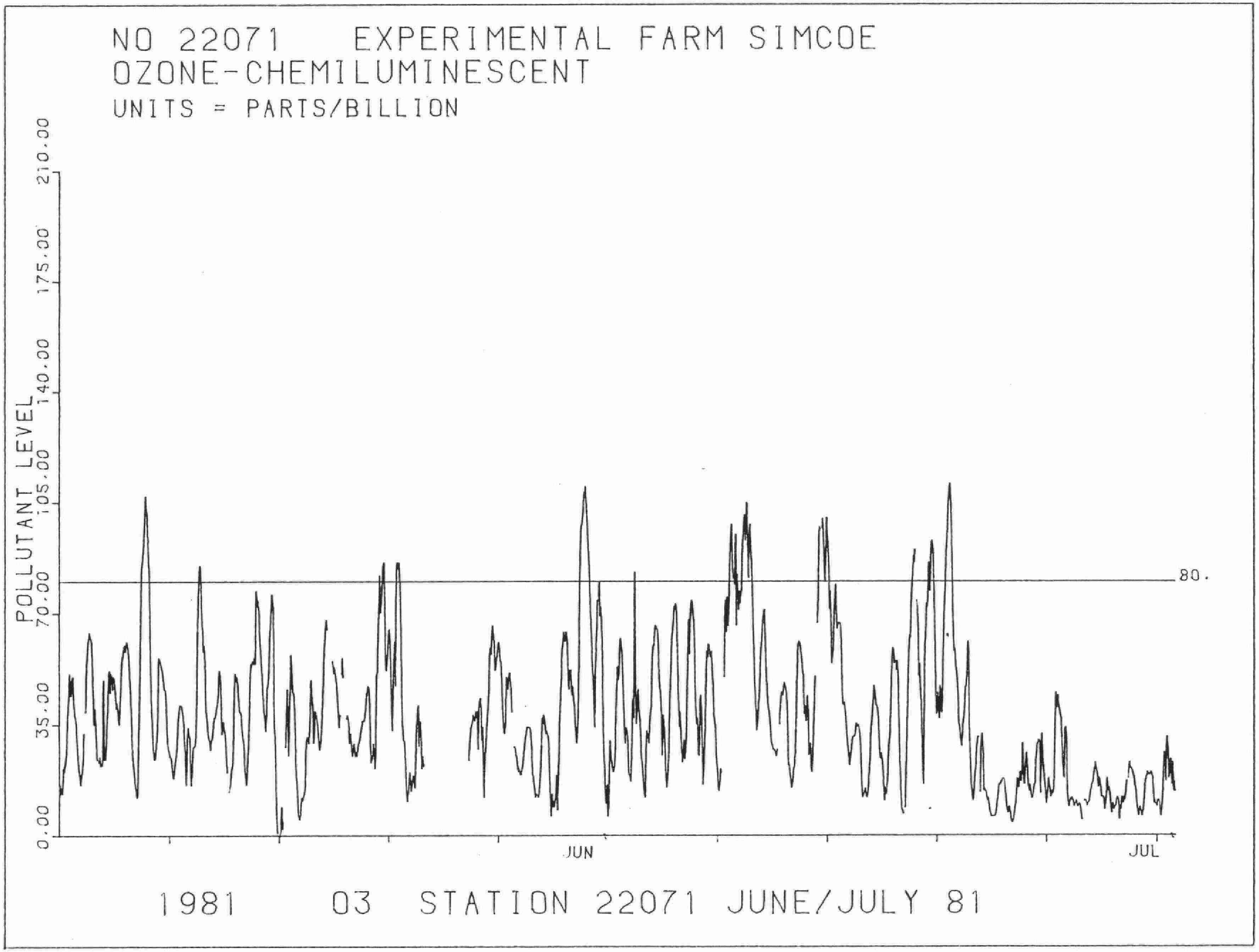
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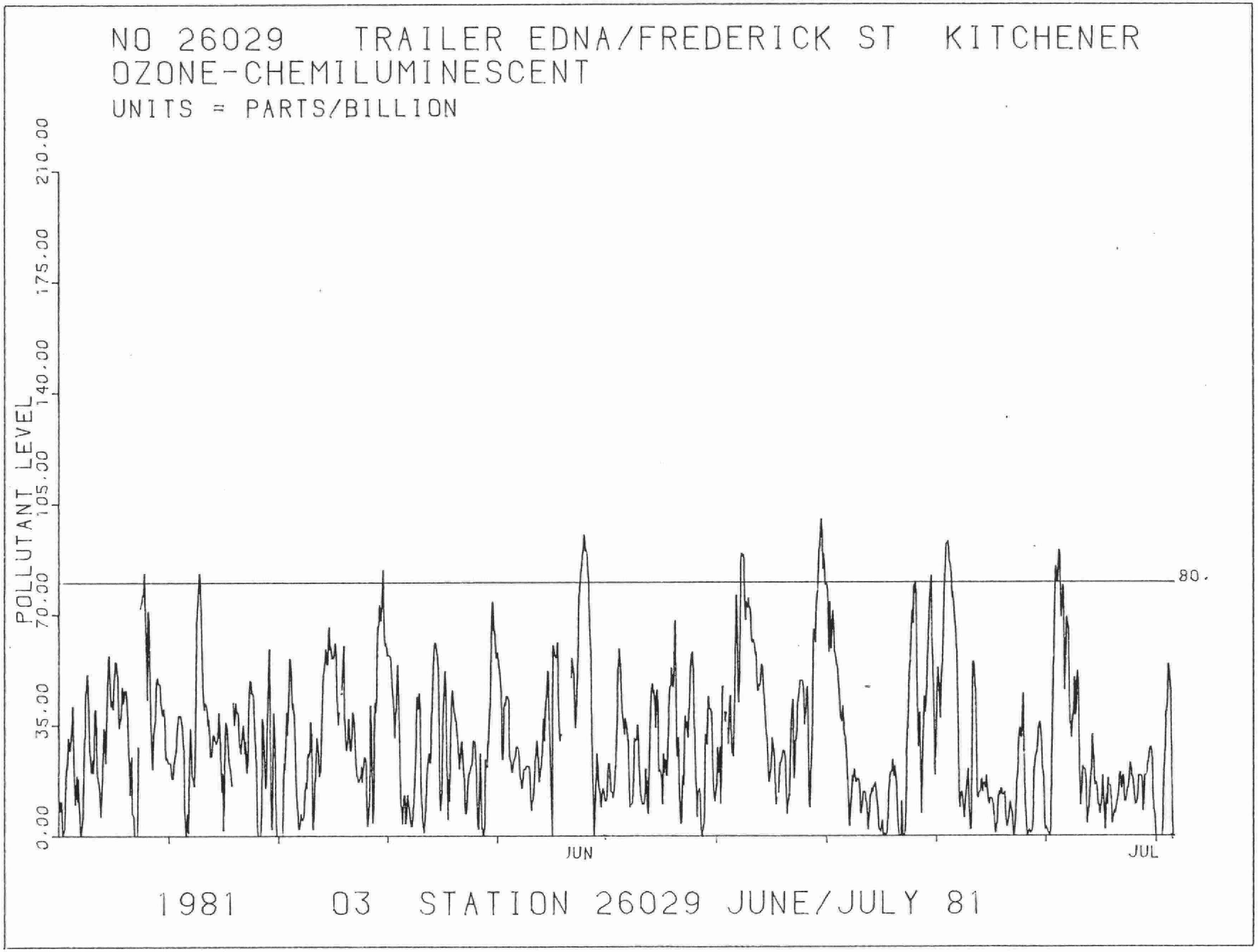
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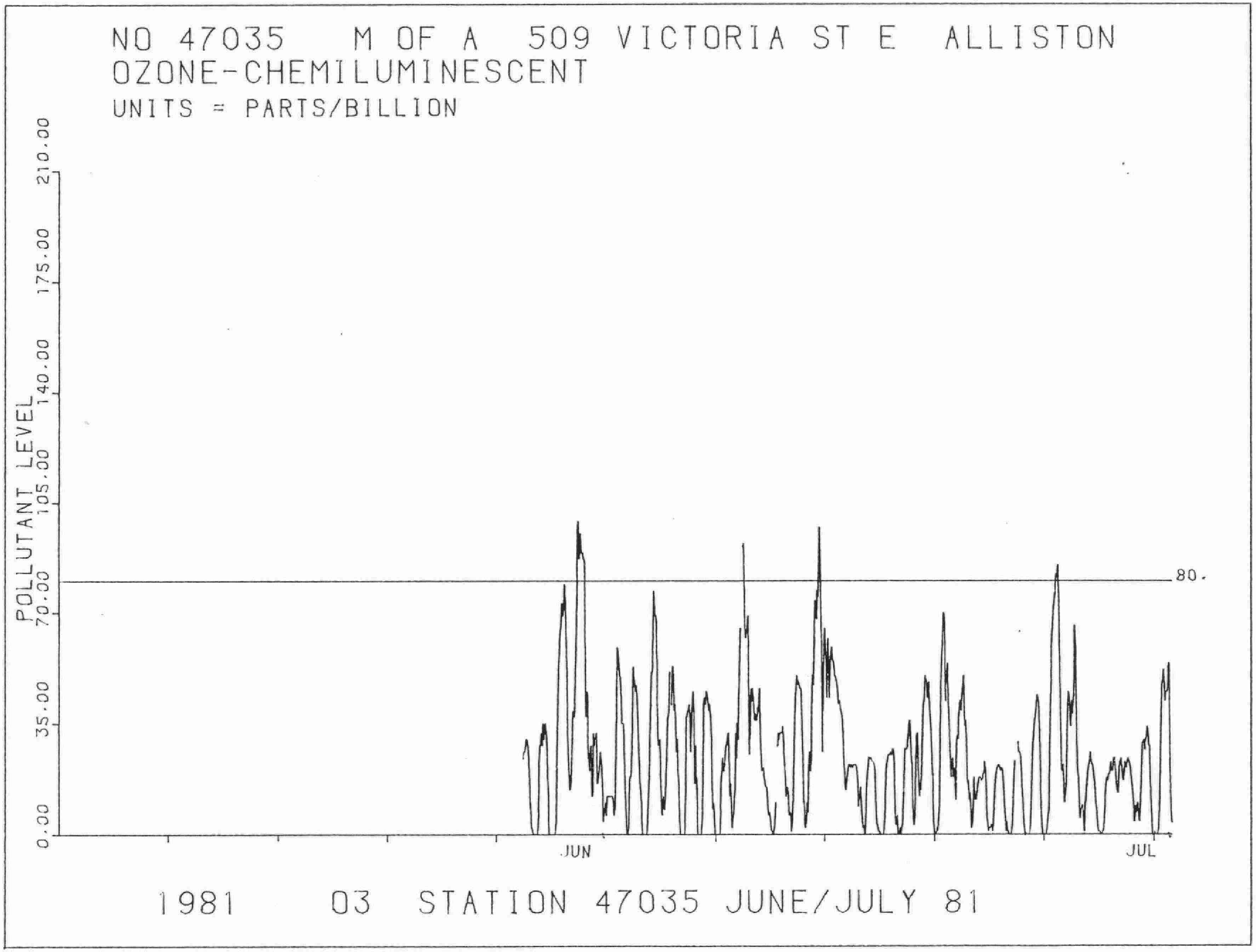
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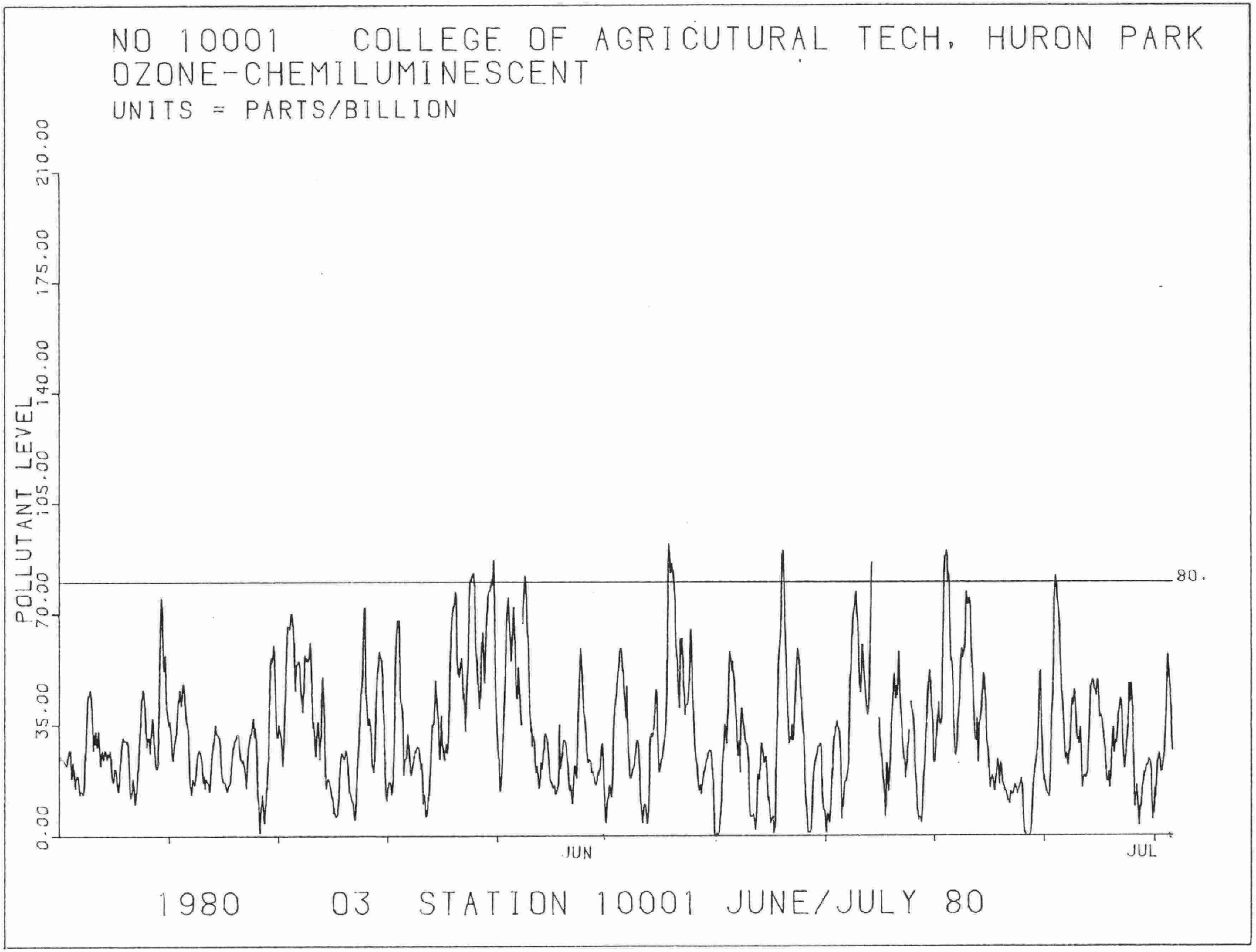
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210.00
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JUN
JUL
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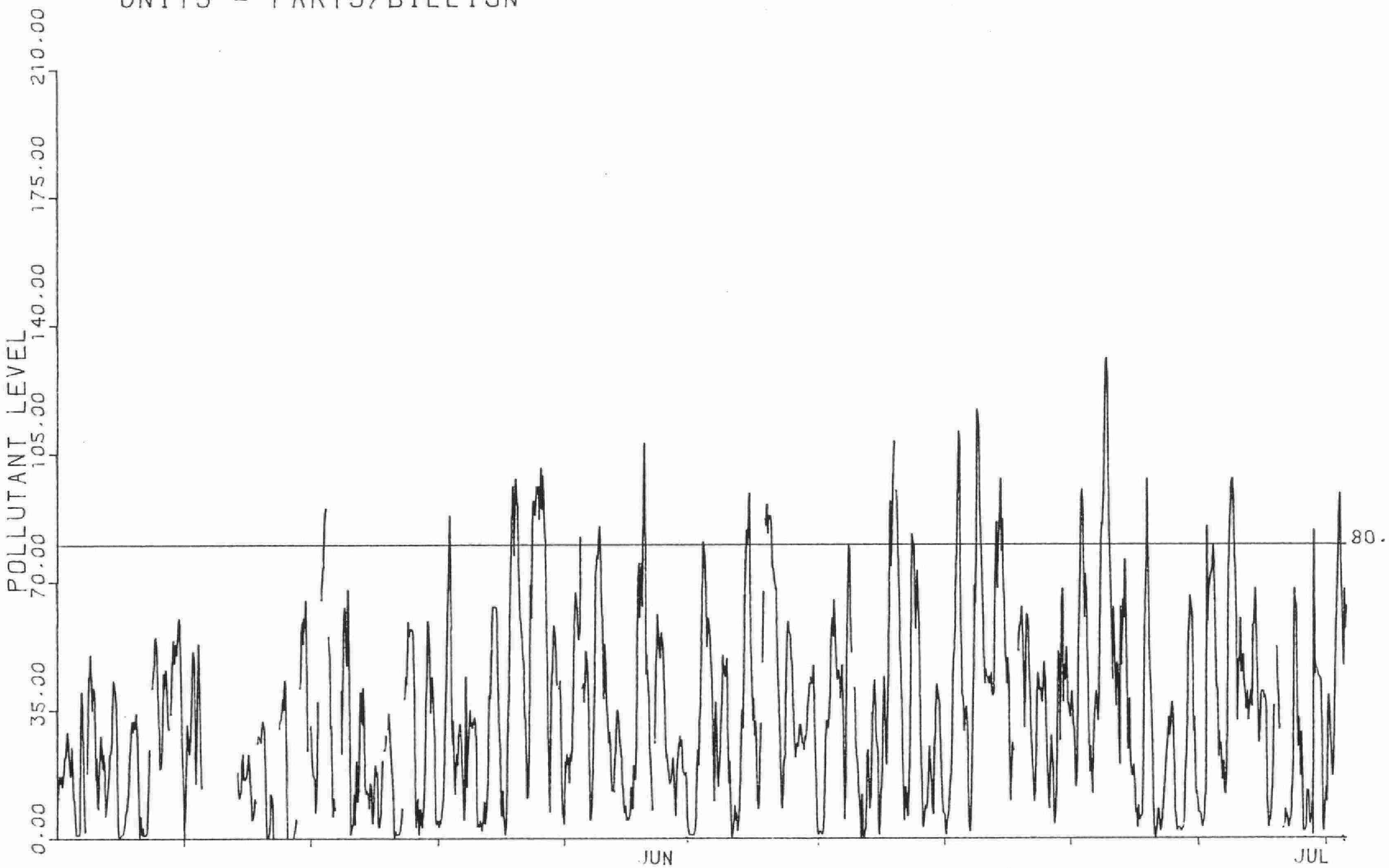
OZONE-CHEMILUMINESCENT
UNITS = PARTS/BILLION



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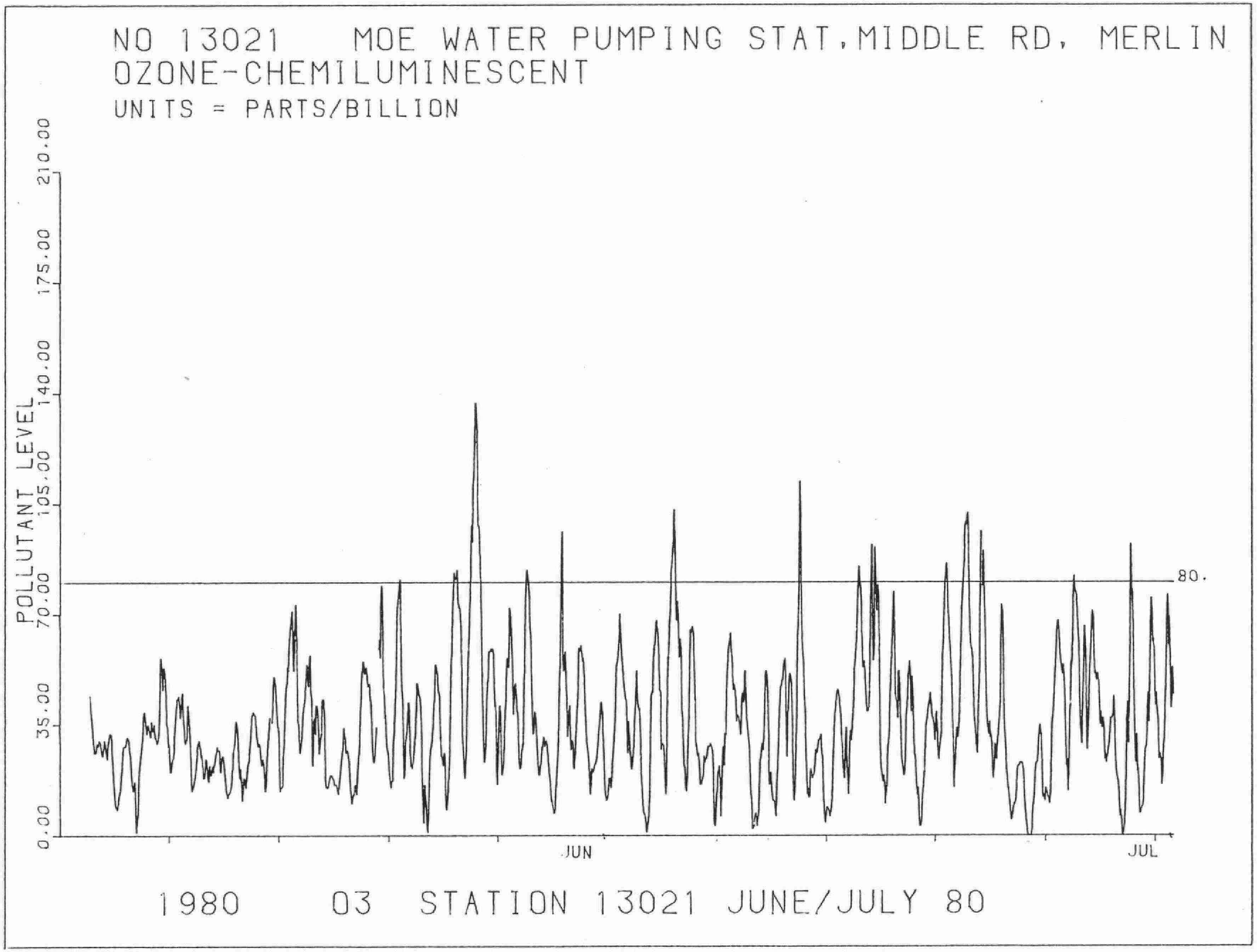
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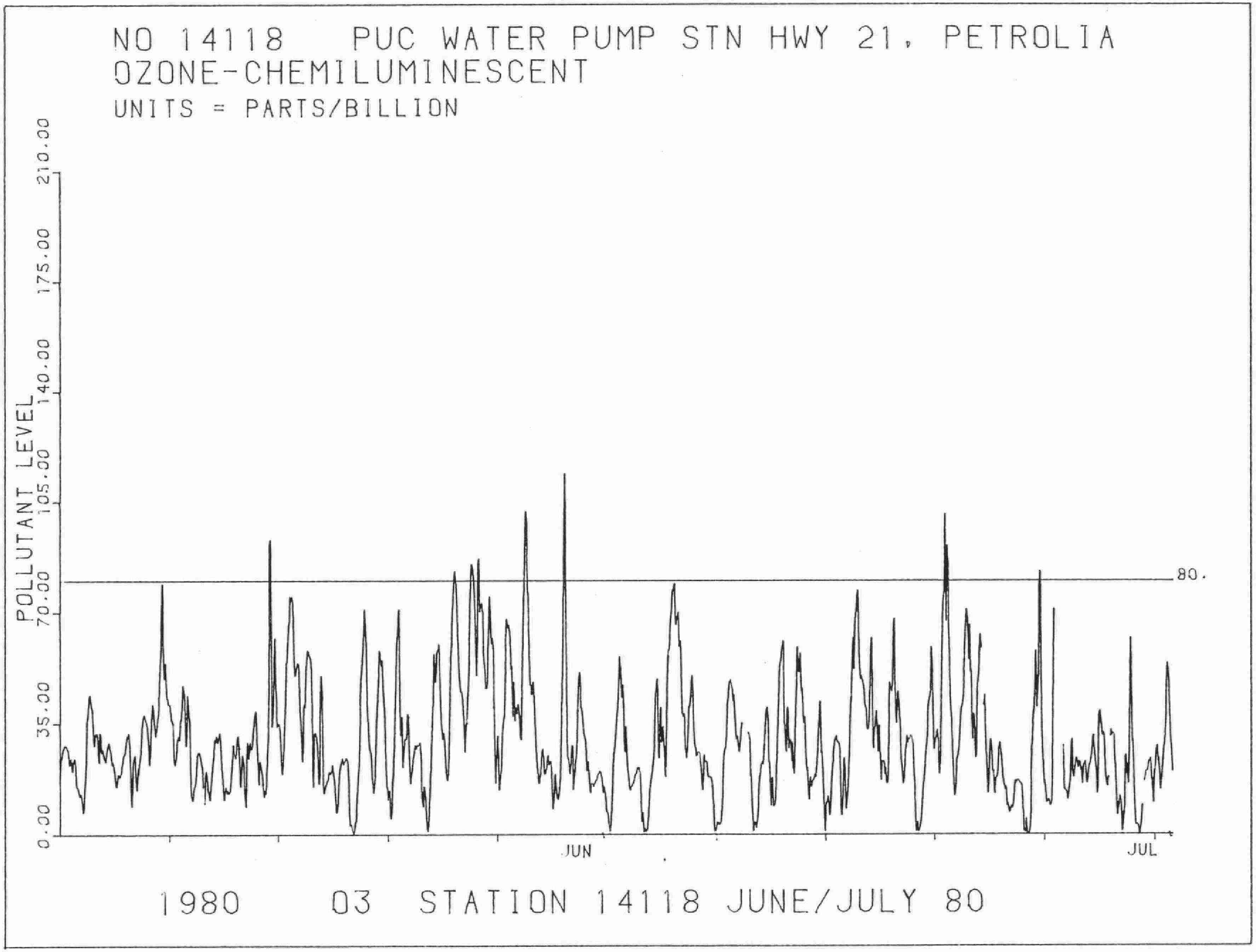
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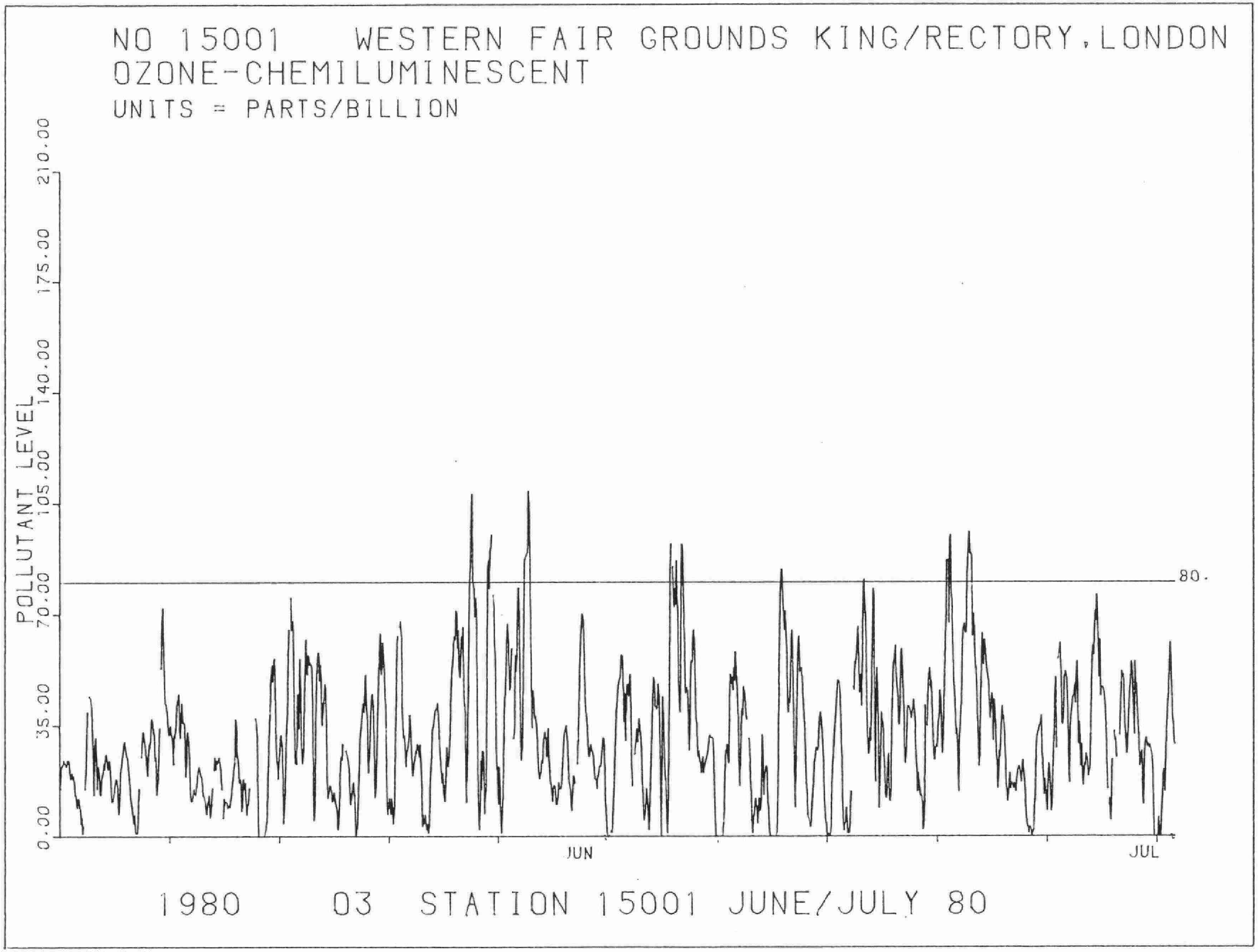
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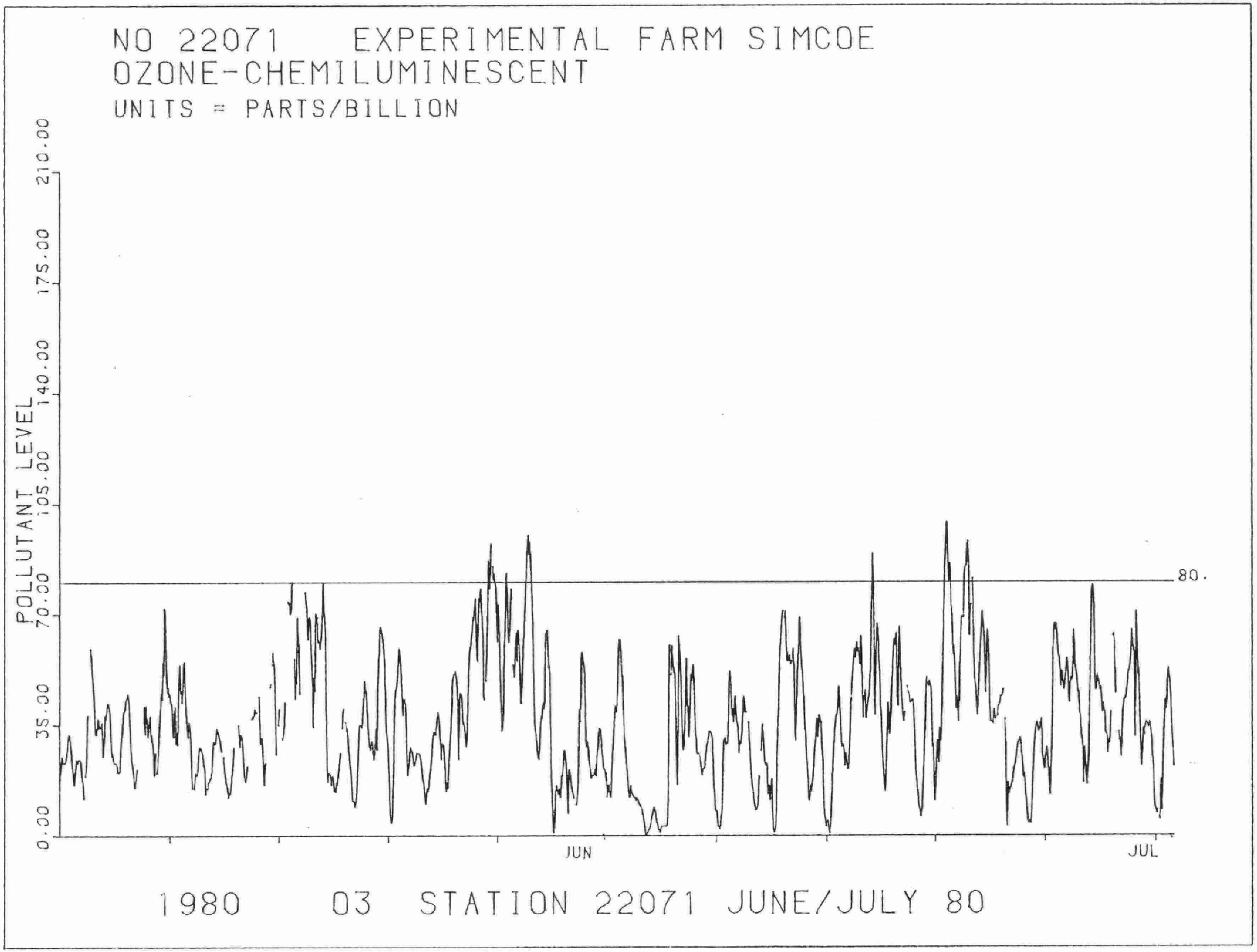
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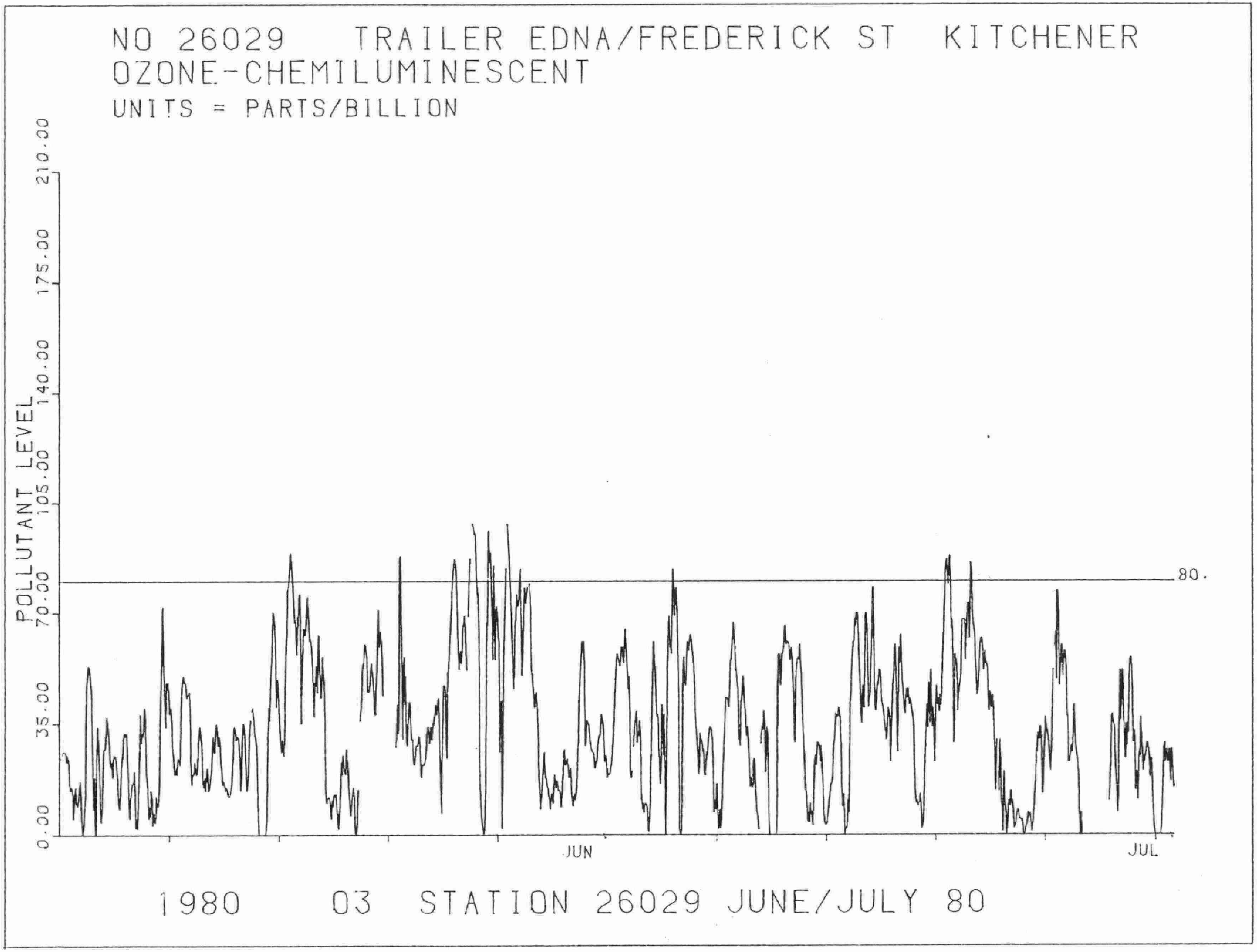
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POLLUTANT LEVEL
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1980 03 STATION 26029 JUNE/JULY 80

Ontario

Ministry
of the
Environment

135 St. Clair Avenue West
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M4V 1P5

ASSESSMENT OF OZONE INJURY ON POTATO AND TOMATO PLANTINGS ACROSS SOUTHERN ONTARIO: 1982

During July 12-15, 1982, the severity of ozone injury was assessed on potato and tomato crops in the primary growing areas across southwestern and central Ontario. The potato evaluation locations included the Harrow, Ridgetown, Simcoe, Cambridge and Kettleby Research Stations as well as commercial growers' fields near Thedford, Port Stanley and Alliston. Tomato plantings were evaluated at the Harrow, Ridgetown and Simcoe experimental stations and commercially grown fields near Leamington, Dresden and Reece's Corners.

At each location, two or three representative plants usually were examined but only one plant was thoroughly assessed. The injury assessment, as in other years, involved examining all true leaves on the main vine and estimating the average percentage injury to each affected compound leaf. The injury values and the number of injured and healthy leaves were recorded and, subsequently, the average percentage injury to the plant was calculated by multiplying the percentage of leaves injured times the average percentage injury to all affected leaves.

Also, during the initial survey, an injured leaflet from a mid-plant position was collected from a Kennebec potato plant growing at Harrow and Port Stanley and from a Monona plant growing at Alliston. An injured leaflet from a younger leaf also was collected from a Trent potato plant at Ridgetown. The samples were submitted for histological examination.

During the final week of July potato and tomato varietal trials were reassessed for injury at the Cambridge and Simcoe Research Stations, respectively with additional potato reassessment near Dogpatch, to the southwest of Simcoe. At Cambridge, specimens of injured leaves (Trent variety) were collected for the herbarium.

The mid and late July injury assessment results for both crops are shown in attached Tables 1 and 2.

Potatoes

The assessment in mid-July revealed the presence of ozone injury on potato foliage at all locations except Thedford and Kettleby.

At Harrow, Ridgetown, Simcoe and Cambridge, the predominant injury to potato plants was characterized by either grey or copper (rust) coloured, small, irregular sized lesions which were primarily confined to older lower and/or middle positioned leaves. On all cultivars examined at Simcoe and on at least three at Ridgetown the younger foliage also exhibited injury. On more severely injured leaves, the lesions were scattered and had coalesced over the undersurface and in some cases had become bifacial. At Simcoe, most leaves on Norland plants were almost entirely necrotic. On compound leaves displaying a lesser degree of injury, usually only a few lesions were observed at either the terminal or basal end of the affected leaflets.

At Port Stanley, Kennebec plants exhibited grey coloured, pin head sized lesions scattered over the undersurface of most leaflets on most leaves. Similar injury also was detected on Monona plants at Alliston. However, at this site, the lesions were only present on the three oldest leaflets of a few upper-middle positioned leaves. A few cultivars growing at Ridgetown and Simcoe also posessed a few leaves with upper surface stippling.

On potato trials at Simcoe it was reported by Mr. A. McKewan, of the Research Station, that the injury occurred during early July. He subjectively rated the plots and, of the commercial varieties, found Norlands to be extremely sensitive, Conestoga and Jemseg to be moderately susceptible and Campbell 13 and Superior plants to be fairly resistant. The injury at Harrow also occurred reportedly during early July.

During the mid-July survey, the most severe foliar injury was detected on Norland plants growing at Simcoe (78%) and Ridgetown (8.7%). At all other locations, the average injury to affected plants was less than 2%.

At the end of July, the reassessment of the potato trials at Cambridge revealed the injury to be generally more severe. Ten varieties were examined with nine displaying undersurface injury as opposed to only one variety during the earlier visit. All affected varieties exhibited grey and copper coloured lesions on middle positioned leaves with three varieties (Norland, Trent, Yukon Gold) also displaying the injury on younger foliage. Two varieties also manifested some black stipples on the upper surface of some middle positioned leaves. Norland (7.2%) and Yukon Gold (4.1%) plants exhibited the most severe foliar injury whereas Russet Burbank was the most resistant cultivar. At other locations, Ruset Burbank plants also were found to be the least susceptible to ozone injury.

During late July, in the Simcoe area, the average foliar injury to commercially grown potato crops (Kennebec, Yukon Gold) was estimated at 1.5% which was less severe than that detected earlier on some varieties at this site. Kennebec plants exhibited a similar type and pattern of injury as corresponding plants examined earlier at Port Stanley. In general, the field observations were supported by the histopathological findings which revealed the undersurface foliar lesions on potato plants at Harrow, Ridgetown and Alliston to be characteristic of ozone injury development.

The histopathology results further revealed that the grey, pin head sized lesions observed over the under surface of most leaves on Kennebec plants at Port Stanley were not totally typical of ozone but did suggest that ozone probably was the causal agent.

Tomatoes

During mid-July the previously described atypical undersurface foliar ozone injury was detected on foliage of tomato plants growing at all lcoations but Dresden. Tomato plants in the Simcoe area were the most severely injured with Harvestvee being the most severely affected variety (1.4%).

The injury was characterized by shiny, either grey or copper coloured, irregular sized lesions which were primarily confined to older leaves. Only at Leamington and Simcoe was younger foliage on some cultivars also injured.

On nearly all plants examined during mid-July, most injured leaves displayed the lesions at the terminal or basal end of the affected leaflets.

By mid-July, the injury to affected tomato crops across southwestern and central Ontario ranged in severity from 0.1 to less than 1.5% (Table 2).

At the end of July, the injury in the Simcoe area was slightly more severe, the average foliar injury to the most adversely affected tomato plant (Harvestvee) being about 2%.

Mimicking Symptoms

During the course of the investigation some potato and tomato plants at some locations also displayed a glazed bronze coloured injury on

the undersurface of affected leaves. However, the observations as in other years revealed the glazed-bronze injury to be primarily confined to the under side of turned-up leaflets exposed to sunlight, with the tissue on the shaded or unexposed side of the veins being free of the injury. On the basis of the lack of any pattern vis-a vis tissue maturity and the known ability of sunlight to cause scald symptoms on normally shaded undersurface leaf tissues, ozone was ruled out as a factor in the appearance of these symptoms.

Injury Severity

Comparison of the two years' corresponding injury values for potatoes (Table 1) revealed an overall increase in the number of potato cultivars injured and in injury severity during 1982. However, the only marked increase in severity was detected on potato plants growing at the Simcoe Research Station.

On tomato crops (Table 2), the comparison failed to reveal any marked difference between the two years' injury ratings.

Ambient Ozone Data

The attached Table 3 shows the days and corresponding number of hours (9 a.m. - 6 p.m.) ambient ozone at or above 80 ppb was monitored at Merlin (Ridgetown area), Simcoe and Alliston during June 23 - July 29, 1982.

As the Table shows, potentially plant injurious ozone levels were monitored at each location on at least one occasion prior to the initial assessment of potato and/or tomato crops in these areas. The data also reflect that Simcoe was the most severely affected area (which supported the field observations), and that high ozone levels had occurred across

Central Ontario following the mid-July survey, supporting the increase in injury severity detected on tomato plants at Simcoe, and on potato plants at Cambridge, at the end of July.

In contrast to the 1981 and 1982 injury comparison which revealed an overall increase in injury severity to potato crops during 1982, the ozone data presented in attached Table 4 reflect an overall reduction in the number of days and hours ambient ozone at or above the ministerial criterion (80 ppb) was recorded in the Ridgetown, Simcoe and Alliston areas in June and July during 1982 compared to 1981.

Summary

In summary, the preceeding field observations, supported by the histopathological findings and the ambient ozone data (Tables 3 and 4), confirmed the presence of ozone injury to potato and tomato plants at most sites across southwestern and central Ontario during 1982. The most severe foliar injury was displayed by both crops at the Simcoe Research Station. Here, potato plants displayed injury in the 1-78% range whereas the injury to the most severely affected tomato plant (Harvestvee) was less than 2% by the end of July. These and the other assessment results suggest that, in Ontario, potato crops generally are more sensitive to ozone injury than are tomatoes. As in other years, Norland potato plants displayed the highest degree of sensitivity to ozone whereas, during 1982, Russet Burbank was found to be the most resistant potato cultivar. During 1982, an overall higher severity of injury was exhibited by potato crops whereas tomato crops displayed similar injury compared to 1981.

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Vegetation Assessment Unit
Phytotoxicology Section

RNE/hm

Attach.

PH/35/7

TABLE 1

Severity of Ozone Injury Assessed on Potato Plantings across Southwestern and Central Ontario during July, 1982 and on Corresponding Varieties during 1981.

Location/date 1981; 1982	Variety	Percent Injury: Most Severely Affected leaf 1981	Most Severely Affected leaf 1982	No. of Injured Lvs. - Total Inj. to Inj. Lvs. 1981	No. of Injured Lvs. - Total Inj. to Inj. Lvs. 1982	Avg. Inj. to all Lvs. on Plant/Vine 1981	Avg. Inj. to all Lvs. on Plant/Vine 1982
Harrow July 6; July 12	Kennebec	-	5.0	-	7-16	0	1.6
	Superior	7.0	3.0	7-13.0	8-9.5	1.3	0.1
Thedford July 7; July 13	Cheiftain	0.5	-	2-1.0	-	0.1	0
	Katahdin	0.5	-	2-1.0	-	0.1	0
	Kennebec	-	-	-	-	0	0
	Netted Gem	-	-	-	-	0	0
	Superior	-	-	-	-	0	0
Ridgetown July 6; July 13	Belleisle	-	4.0	-	6-1.7	0	0.8
	Cheiftain	-	0.5	-	1-0.5	0	0.1
	Jemseg	-	8.0	-	8-21.0	0	0.3
	Katahdin	-	0.5	-	7-3.5	0	0.3
	Kennebec	1.0	0.5	1-1.0	3-1.5	0.1	0.2
	Norchip	1.5	1.0	2-2.0	4-2.5	0.2	0.1
	Norland	2.0	15.0	4-5.5	10-8.7	0.7	8.7
	Rideau		0.5		1-0.5		0.1
	Sebago	-	-	-	-	0	0
	Simcoe		7.0		4-19.0		4.8
	Superior	0.5	0.5	1-0.5	4-2.0	0.1	0.2
	Trent		10.0		6-31.5		3.5
	Yukon Gold	1.0	5.0	2-2.0	8-13.5	0.2	1.1
Port Stanley July 7; July 13	Kennebec	-	3.0	-	11-22.0	0	1.6
	Superior	1.0	-	3-2.0	-	0.4	0
Simcoe July 7; July 15	Conestoga		25.0		11-106.0		9.6
	Kennebec	-	10.0	-	15-56.0	0	4.0
	Norchip	-	13.0	-	8-44.0	0	5.5
	Norland	0.5	80.0	2-1.0	10-780	0.1	78.0
	Russet burbank		2.0		6-8.0		1.0
	Shepody		12.0		11-51.5		4.7
	Superior	-	10.0	-	6-30.0	0	4.3
	Yukon Gold	-	20.0	-	12-88.0	0	7.3
Dogpatch (SW of Simcoe) -; July 29	Kennebec		3.0		11-17.0		1.5
	Yukon Gold		5.0		7-15.0		1.5
Cambridge July 7; July 14 (July 30; July 28)	Jemseg	- (2.0)	- (8.0)	- (3-3.5)	- (6-12.5)	0 (0.7)	0 (1.4)
	Kennebec	(2.0)	- (3.0)	(5-4.0)	(9-14.5)	(0.5)	0 (1.1)
	Norchip	(10.0)	- (10.0)	(5-17.0)	- (8-26.5)	(2.4)	0 (2.2)
	Norland	1.0 (30.0)	(13.0)	7-5.0 (6-118.0)	(10-72.0)	0.5 (20.0)	(7.2)
	Rideau	0.5 (-)	- (1.0)	2-1.0 (-)	- (4-3.5)	0.1 (0)	0 (0.3)
	Russet burbank		- (-)		- (-)		0 (0)
	Simcoe		0.5 (2.0)		2-1.0 (8-9.0)		0.1 (0.8)
	Superior	0.5 (-)	- (1.0)	1-0.5 (0)	- (7-4.0)	0.1 (0)	0 (0.6)
	Trent		- (6.0)		- (9-19.5)		0 (2.2)
	Yukon Gold	0.5 (1.0)	- (10.0)	1-0.5 (2-1.5)	- (10-45.0)	0.1 (0.3)	0 (4.1)
Kettleby July 8; July 14	Kennebec	-	-	-	-	0	0
	Norchip	-	-	-	-	0	0
	Russet burbank		-		-		0
	Superior	-	-	-	-	0	0
	Yukon Gold	-	-	-	-	0	0
Alliston July 3; July 17	Monona		0.5		3-1.5		0.2
	Netted Gem		-		-		0
	Norchip	-	-	-	-	0	0
	Shepody		-		-		0
	Superior	-	-	-	-	0	0

TABLE 2

Severity of Ozone Injury Assessed on Tomato Plantings across Southwestern and Central Ontario during July, 1982 and on Corresponding Varieties during 1981.

Location/date	Variety	Percent Injury					
		Most Severely Affected leaf		No. of Injured Lvs. - Total Inj. to Inj. Lvs.		Avg. Inj. to all Lvs. on Plant/Vine	
1981; 1982		1981	1982	1981	1982	1981	1982
Harrow	Campbell 28	0.5	0.5	1-0.5	3-1.5	0.1	0.2
July 6; July 12	Heinz 2653	-	1.5	-	4-4.0	0	0.2
	Ontario 7710		-		-		0
*Leamington	Campbell 28		1.0		5-3.0		0.4
- ; July 12	Heinz 1409		1.0		4-3.0		0.4
	Heinz 1630		3.0		5-7.5		1.1
	Heinz 7038		-		-		0
	Hunt 208F		0.5		2-1.0		0.1
	New Yorker		0.5		6-3.0		0.3
	TH 318		0.5		1-0.5		0.1
*Dresden	Campbell 28		-		-		0
- ; July 13	Campbell 37		-		-		0
	Campbell 793		-		-		0
Reeces Corners	Heinz 1350	0.5	0.5	1-0.5	2-1.0	0.1	0.1
	Jackpot	0.5	0.5	2-1.0	2-1.0	0.1	0.1
July 7; July 13	Redpack	0.5	2.0	2-1.0	1-2.0	0.1	0.3
Ridgetown	Bellestar		-		-		0
July 6; July 13	Campbell 28	-	1.0	-	1-1.0	0	0.1
	Campbell 37	1.0	0.5	2-2.0	1-0.5	0.3	0.1
	Heinz 1706	-	-	-	-	0	0
	Heinz 2653	0.5	-	1-0.5	-	0.1	0
	Hunt 208F		-		-		0
	TH 318		-		-		0
	Veeking		-		-		0
Simcoe	Bellestar		3.0 (3.0)		4-6.5 (6-9.5)		1.1 (1.4)
July 9; July 15	Bonnyvee		0.5 (0.5)		1-0.5 (2-1.0)		0.1 (0.1)
- ; (July 29)	Campbell 28	-	- (0.5)		- (2-1.0)	0	0 (0.1)
	Harvestvee	1.0	5.0 (8.0)	1-1.0	5-9.5 (6-16.5)	0.2	1.4 (1.8)
	Heinz 2653	0.5	0.5 (3.0)	1-0.5	1-0.5 (6-9.5)	0.1	0.1 (0.8)
	Hunt 208F		0.5 (-)		1-0.5 (-)		0.1 (0)
	Jackpot		- (6.0)		- (3-8.5)		0 (1.1)
	New Yorker	1.0	0.5 (3.0)	1-1.0	1-0.5 (1-3.0)	0.1	0.1 (0.8)
	Ontario 773		- (0.5)		- (2-1.0)		0 (0.1)
	TH-318		0.5 (-)		3-1.5 (-)		0.2 (0)
	Veeking		- (0.5)		- (2-1.0)		0 (0.1)
	Veepro		1.0 (0.5)		3-2.0 (1-0.5)		0.3 (0.1)

*Tomato plantings were not examined at this location during 1981.

RNE/as: PH 22-16

TABLE 3

Summary of Ozone Data for Three Locations in Southwestern and Central Ontario from June 23-July 29, 1982

		No. of Hours (9 a.m. - 6 p.m.) Ozone Concentration at or above 80 ppb		
Date		Merlin (Ridgetown area)	Simcoe	Alliston
June	23			
	24			
	25		3	
	26			
	27			
	28		4	1
	29			
	30			
July	1			
	2			
	3			
	4			
	5		3	
	6		2	
	7			
	8			
	9			
	10	4	4	
	11			
	12			
R*	13			
	14	2		2
S	15		5	
	16	2	7	8
A	17		1	
	18			
	19			
	20			
	21			
	22			
	23			
	24			
	25	1	6	
	26			
	27			
	28			
	29			

* Assessment date: (R) - Ridgetown; (S) - Simcoe; (A) - Alliston

TABLE 4

Number of Occasions Ambient Ozone at or above 80 ppb was Recorded at Merlin, Simcoe and Alliston during June and July of 1981 and 1982

Ozone Monitoring Sta. (No.)	No. of Consecutive Hours O_3 at or Exceeding 80 ppb											
	1981						1982					
	June			July			June			July		
	1-3	4-8	8	1-3	4-8	8	1-3	4-8	8	1-3	4-8	8
Merlin-Ridgetown (13021) area	0	0 (0)* 32.5***	0	5	2 (21)* 43.7**	0	0	0 (0)* 1.3**	0	3	1 (9)* 0.9**	0
Simcoe (22071)	4	1 (36)* 9.2**	2	5	3 (56)* 36.4**	3	4	2 (15)* 0.8**	0	6	4 (38)* 0.4**	0
Alliston*** (47035)	0	0 (10)* 0.1**	1	2	1 (9)* 0.9**	0	1	0 (2)* 0.8**	0	2	0 (11)* 0.4**	1

* No. of hours during month ambient ozone was recorded at or exceeding 80 ppb in the ambient atmosphere.

** Percentage of data invalid

*** Recording commenced in 1981 on June 26 and in 1982 on June 23.